ESTONIAN UNIVERSITY OF LIFE SCIENCES

Institute of Agricultural and Environmental Sciences

Kertu Kruus

PROPOSAL OF GREEN INFRASTRUCTURE PLANNING PRINCIPLES IN KOPLI AND PALJASSAARE DISTRICT

ROHETARISTU PLANEERIMISE PÕHIMÕTETE ETTEPANEK KOPLI JA PALJASSAARE ASUMIS

Master’s Thesis
Curriculum in Landscape architecture

Supervisors: Junior researcher Gloria Niin, MSc
Lecturer Peeter Vassiljev, MSc
Professor Mart Külvik, PhD

Tartu 2018

CONTENTS

ACKNOWLEDGEMENTS

The current thesis is written and submitted to the Department of Landscape Architecture in Estonian University of Life Sciences to complete the curriculum in Landscape Architecture study program and gain a degree in Master of Science in Engineering.

The author of the thesis would like to thank all the people who offered help and support throughout the writing process:

The supervisors of the paper: Gloria, thank you for helping to organise the structure of the work, for useful suggestions and quick feedback when it was most needed; Peeter, thank you for helping to begin with the writing process, for long consultations during busy times, for many guidelines and discussion sessions; Mart, thank you for many guidelines, for regular check-ups on the progress and for helping to bring attention to the most important aspects.

Furthermore, people who offered constant advice, support and many helpful suggestions: Liisa and Kaja - the fellow sufferers, family and especially Janika Kruus for keeping my English in check, all close friends and other family members. Thank you!

INTRODUCTION

This thesis is proposing a response for green infrastructure planning in Kopli and Paljassaare districts by phrasing new ecological and recreational planning principles that are based on the interpretation of drivers, assessment of pressures, states, impacts and political response of 2030. Proposed green infrastructure planning principles can be applied to located conflicting areas for mitigating the problematic conditions and threats in the political response of 2030.

Results about the problematic conditions are gathered by mapping recreationally valuable landscape units; applying MAES indicator framework and mapping service providing units, recreation opportunities, quality of recreational areas and usage of green areas. Five detailed plans were considered as a political response. Revealed problematic conditions are then paralleled with threats of the political response. Conflicting and synergic areas are then mapped. Ecological and recreational planning principles are proposed to mitigate the problematic conditions and the prognosis of threats in conflicting areas.

Many sources about green infrastructure planning is provided in the reports of EU Biodiversity Strategy of 2020. The EU Biodiversity Strategy target no 2, action no 5 offers five reports about "Mapping and Assessment of Ecosystems and their Services (MAES)". These reports provided the basis for the thesis. Common International Classification of Ecosystem Services (CICES) was used to assess the ecosystem services in the area. Recreation opportunities were assessed as ecosystem services, as a public asset and classified by quality using the Recreation Opportunity Spectrum.

In addition to the recreational and aesthetic factors in planning outdoor spaces, the concept of urban green infrastructure is starting to play a more important role each decade (Herslund *et al.* 2017). Maintained urban ecological areas in the city are important for carrying out natural processes, standing against negative human activities and offering residents a possibility to be in green open spaces (Peng *et al.* 2017, p. 23). Green infrastructure is a network consisting of nature protected sites, nature reserves, greenspaces, greenways and linkages that consists of all features that serve as a wildlife migration corridor (Dover 2015: p. 2).

Public green parks, alleys, cemeteries and urban woodlands are home to many animals and insects – production of organic matter is an ongoing process. The existence of reachable recreational areas in a district is starting to play a more important role for the residents - people are more aware of the positive effect of outdoor activities on health. Areas near recreational facilities have also higher economic value (Tallinn *et al.* 2008).

Large industrial, private port and national defence grounds in Northern Tallinn occupy already most of the land – it is important to take account green infrastructure planning in the surrounding areas. New developments plan to densify the district mostly with residential housing. Green zones between those areas play a crucial role in preserving the ecological quality of the district. Green connections between parks, nature reserve and seaside need to be restored, maintained or built. Growing urban sprawl and built infrastructures break the connectivity between the few green areas left (Europarc Federation 2018).

Many detailed plans are in process or already established in Kopli and Paljassaare peninsula. The complex solution for recreational and ecological features has to be analysed as a hole – through-out Kopli and Paljassaare peninsula to achieve improved social and ecological outcomes. The area is soon in-demand for urban construction land due to its great potential because of the closeness to the sea and city centre. Well-planned green structure increases the land values for upcoming plots. Northern Tallinn is developing within itself not spreading – the sea is the border. The quality of the development has to be high, well thought-through and also restoring already done damage.

The main research task is to propose a response for green infrastructure planning in Kopli and Paljassaare districts by phrasing new ecological and recreational planning principles and locating the conflicting and synergic areas. For achieving the main research task following research questions were stated:

1. Which ecosystem services are valid in the green infrastructure of Northern Tallinn district, what is their condition and where are these services distributed?
2. Which recreational opportunities are valid in the green infrastructure, which landscape units are recreationally valuable and used by local residents and where are these features distributed?
3. Where are the conflicting and synergic areas considering the studied aspects of the green infrastructure?
4. Which planning principles need to be considered in the future green infrastructure planning?

1 LITERATURE REVIEW

Following paragraphs describe the different approaches in assessing the topic of urban green infrastructure development. From this literature review, main principles are analysed and gathered in order to form an approach that would be applied to green infrastructure planning in Kopli and Paljassaare district. Due to large volume of the work not all principles and methods are brought out. Chosen approaches are one of the possibilities to follow through the stated research task.

1.1 Green infrastructure

1.1.1 General definitions of green infrastructure

"Green infrastructure is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation. This network of green (land) and blue (water) spaces can improve environmental conditions and therefore citizens' health and quality of life. It also supports a green economy, creates job opportunities and enhances biodiversity. The Natura 2000 network constitutes the backbone of the EU green infrastructure" (European Commission 2016b).

John W. Dover defines green infrastructure as all the environmental resources with separate elements and strategically developed networks of superior green areas including other environmental features: pavements, car parks, driveways, roads and buildings that include biodiverse features and forward ecosystem services (Dover, 2015: p. 3). By this definition every urban element could be a part of the green infrastructure. 'Green to grey' (Dover, 2015: p. 4) approach would assess in addition to the nodes and linkages of the green network also the artificial grey elements in the city that could be transformed into a something that improves our living environment.

In addition to recreational features, green infrastructure holds within many natural or restored ecosystems and landscape elements (wetlands, woodlands, waterways, wildlife habitats, parks, nature reserves, wildlife corridors, wilderness areas, forests, farms, ranches, view sheds and greenways) which are combined in the system of hubs, links and sites (figure 1.) (Benedict 2012: p. 12). These landscape elements forward ecosystem services and their conservation should not only be done because of the effect people have on them but also to include the benefits that society depends on (Nahuelhual *et al.* 2017: p. 211).

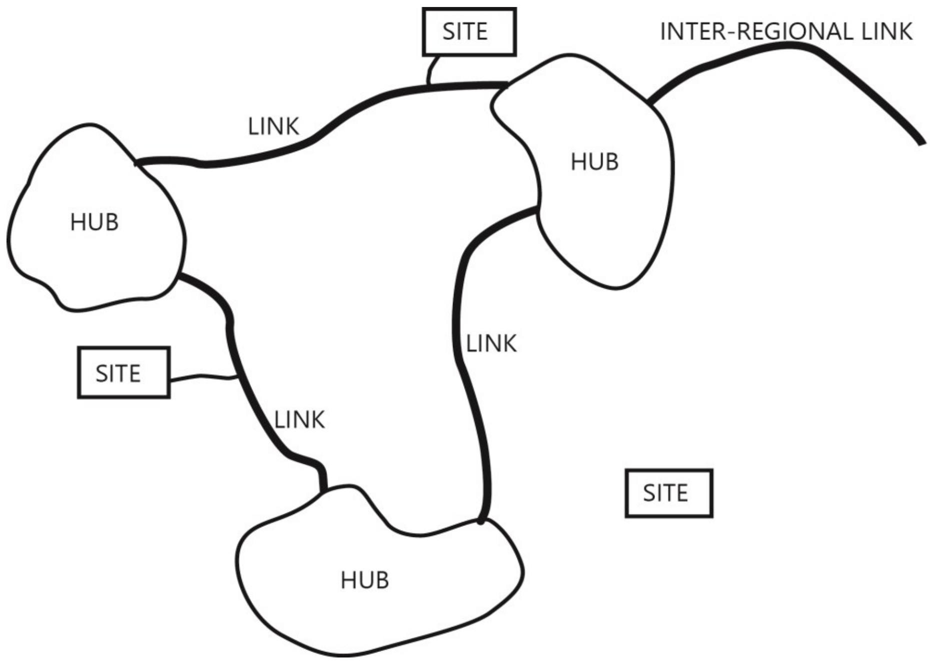

Figure 1. *The system of hubs, links and sites* (Benedict *et al.* 2012: p. 12)

Hubs are the main fundamental components of the green infrastructure with many habitats providing space for many different species; links act as connections between the different parts of the system – they play a vital part in maintaining the ecological flow, biodiversity of species; sites are smaller areas that may not even be connected to the interconnected networks but still contribute to the ecological and social values of the district (Benedict 2012: p. 14).

The identification of biodiversity and ecosystems properties can be done by analysing maps and the existing data about the research area and on the evaluation of its conservation status (Capotorti *et al.*, 2018: p. 2). Green infrastructure strategy can be stated to reach abiotic, biotic and cultural goals (Ahern, 2007: p. 286) and by mapping them, criteria can be developed to locate the existing green network (Jongman 2004: p. 310).

1.1.2 Assessing and mapping methods for green infrastructure planning

1.1.2.1 The DPSIR approach

The abbreviation DPSIR (Driver-Pressure-State-Impact-Response) stands for a conceptual approach that is used for describing the environmental issues and their cause-effect relations (Gari *et al.* 2015: p. 63) with socio-economic fields (Maxim 2009: p. 25). As stated by this methodological framework, demographic, economic and other drivers apply pressure on local biodiversity, natural ecosystems and change their current state, have and impact to the environment and human well-being which in turn persuades decision makers to respond in order to control the effect of drivers and to preserve the current states (figure 2.) (Díaz *et al.*, 2018: 85).

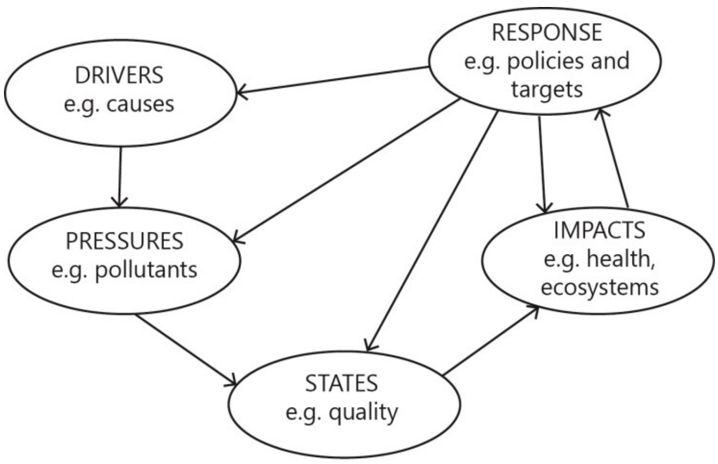

Figure 2. *DPSIR framework* (Gabrielsen, Bosch 2003: p. 8; Gari *et al.* 2015: p. 63)

"Indicators for driving forces specify the social, demographic and economic developments; pressure indicators specify developments in release of emissions, physical and biological factors and the use of resources and land by humans; indicators for states describe the quality and quantity of physical, biological and chemical situation in the research area" (Gabrielsen, Bosch 2003: p. 8). As a consequence of the pressures, states change and have an impact on

the environment (Maxim *et al.* 2009: p. 12). By definitions, impact indicators specify changes that have occurred in environmental functions by human influence (Gabrielsen, Bosch 2003: p. 8). This may bring forward a response from the society that reflects back on drivers, states or impacts through various mitigation, modification, redesign, restoring or healing measures of action (Maxim *et al.* 2009: p. 12).

„The existence of these interrelations also shows that the DPSIR framework, although often presented as a linear chain or a circle, in fact resembles a very complex web of many interacting factors some of which may represent highly non-linear dynamics." (Gabrielsen, Bosch 2003: p. 9)

DPSIR approach can be applied for many reasons - as a diagnostic tool or structural tool – in order to include all fields of studies. Approach can be used as a diagnostic framework for assessing different environmental and social indicators. Structure of the approach is easily understandable and when applied can clarify the entire research.

1.1.2.2 MAES – Mapping and Assessment of Ecosystems and their Services

The EU Biodiversity Strategy of 2020 is stated in order to restrain the loss of biodiversity in Europe. The strategy is divided into 6 targets by EU-COM 2011:

1. *"Target: Protect species and habitats - By 2020, the assessments of species and habitats protected by EU nature law show better conservation or a secure status for 100 % more habitats and 50 % more species.*

2. ***Target: Maintain and restore ecosystems - By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15 % of degraded ecosystems*.**
3. *Target: Achieve more sustainable agriculture and forestry - By 2020, the conservation of species and habitats depending on or affected by agriculture and forestry, and the provision of their ecosystem services show measurable improvements.*
4. *Target: Make fishing more sustainable and seas healthier - By 2015, fishing is sustainable. By 2020, fish stocks are healthy and European seas healthier. Fishing has no significant adverse impacts on species and ecosystems.*
5. *Target: Combat invasive alien species - By 2020, invasive alien species are identified, priority species controlled or eradicated, and pathways managed to prevent new invasive species from disrupting European biodiversity.*
6. *Target: Help stop the loss of global biodiversity - By 2020, the EU has stepped up its contribution to avert global biodiversity loss*."

Target 1 consists of four actions that would commence the EU Biodiversity Strategy 2020. Actions in the first target concentrate on funding and improving the Natura 2000 networks, raise awareness and involve residents, systemize the monitoring and reporting of EU nature laws – so that everything would be up-to-date and under control. For achieving Target 2 – uphold, preserve and increase the biodiversity of established green infrastructure - action plan is formed consisting of three steps (EU-COM 2011):

- *"Action 5 - Mapping and Assessment of Ecosystems and their Services (MAES). Map and assess the state and economic value of ecosystems and their services in the entire EU territory; promote the recognition of their economic worth into accounting and reporting systems across Europe.*
- *Action 6 – Restore ecosystems, maintain their services and promote the use of green infrastructure.*

- *Action 7 – Assess the impact of EU funds on biodiversity and investigate the opportunity of a compensation or offsetting scheme to ensure that there is no net loss of biodiversity and ecosystem services".*

The fourth report of MAES offers guidance for mapping and assessing urban ecosystems, it also includes an indicator framework for assessing the conditions of urban ecosystems and services on a local level (Maes *et al.* 2016). The mapping of Estonian ecosystem services is planned to be performed during 2017 and early 2018, being finalized by spring 2018, managed by Estonian Environment Agency and project manager Lauri Klein (European Commission 2016a).

Two examples are brought out in the MAES report for classifying urban green areas on a site: Typology of Green SURGE project and typology used in Trento (Maes *et al.* 2016). For mapping and assessing the region, three different scales need to be proposed to delineate urban ecosystems: Regional scale (NUTS 1-3, the nomenclature used by Eurostat), metropolitan scale (functional urban area) and urban scale (urban districts and census block) (Maes *et al.* 2016).

The European Urban Atlas provides most of the information about local land use. It provides a spatial and classification basis for locally collected information. Atlas offers a high-resolution land use map of urban areas based on both functional and structural features (figure 3.) (European Union 2011). Information about the ecosystem types is offered by MAES digital atlas (The European Topic Centre on Spatial Information and Analysis 2015).

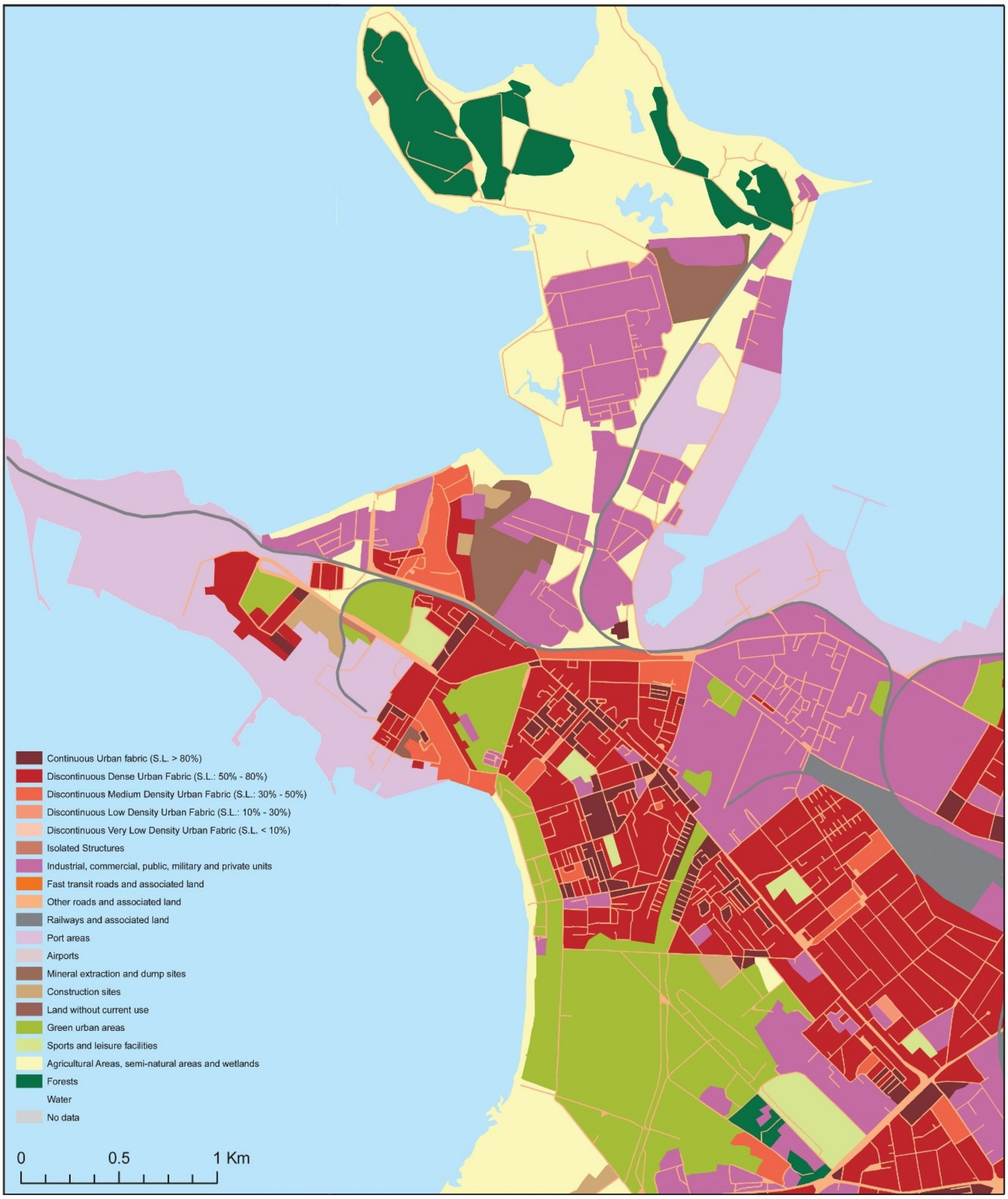

Figure 3. *Urban Atlas land use map of Northern Tallinn* (Urban Atlas 2012)

MAES general operational framework for introductory planning phases consists of (Capotorti *et al.* 2018):

1. *"The identification of ecosystems and biodiversity conservation/restoration priorities – assessing current ecosystem properties;*

2. *The recognition of key demands for socio-economic benefits – assessing current data available about the area, problematic features;*
3. *The detection of existing policies and plans for sustainable development in order to guarantee the territorial relevance and viability of the proposed actions."*

Gathering information about the phases mentioned above, producing maps about the collected data can be used in putting together a database for mapping ecosystem services in the research area.

MAES report introduces a set of key indicators to evaluate the condition of urban ecosystems. These indicators relate to population and land use in order to formulate the condition of an urban ecosystem and characterize built environment (Maes *et al.* 2016). Indicator are divided into pressures and states (annex 1.). MAES fifth report claims that the main pressures are land take, noise and air pollution and main states for the urban ecosystem conditions are urban temperature, air and water quality, noise levels, areal factors that measure the share and built area in connection with population density (Maes *et al.* 2018: p. 25).

Different reports can be used to define references that would clarify the condition of states in urban ecosystem. According to those reports and available documents, a possible evaluation of the states can be proposed. According to the reference, the problematic and positive conditions can be stated.

The MAES fifth report introduces an example on how the indicator framework can be applied in stating the main urban policy objectives: pressures are related to conditions, conditions are strongly connected to the delivery of several urban ecosystem services and ecosystem services can improve human well-being and therefore be connected to policy objectives (figure 4.) (Maes *et al.* 2018).

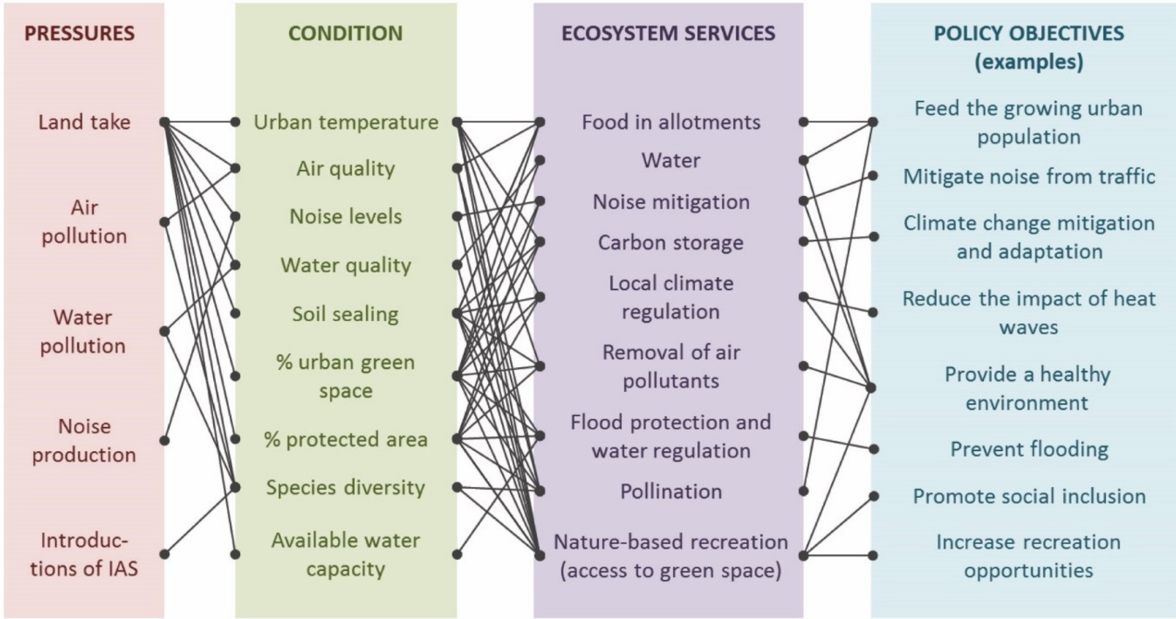

Figure 4. *Synthesis of the links between pressures, conditions and ecosystem services in urban ecosystems* (Maes *et al.* 2018)

MAES indicator framework is a tool for evaluating the condition of urban ecosystems in bigger scale – to have a general overview of the status. Evaluation of living condition is relying on a condition that is good for humans. Reference data about the condition of each indicator can be difficult to find, but some sources are brought out in the MAES report. By applying MAES indicator framework it is easier to understand how different parts of the assessments are connected to each other.

1.1.2.3 The ABC strategy

Taking into account that features of green infrastructure could be divided as abiotic, biotic and cultural elements, "The Abiotic, Biotic and Cultural Strategy" (ABC strategy) was researched further. The strategy, first introduced by Robert Dorney (1976) and later modified by Jamie Bastedo, Gordon Nelson and John Theberge (Ndubisi 2003) is a research survey that helps us ensure that all the following information is considered in the planning process: abiotic, including geographical and earth sciences; biotic, including plant and animal communities; and cultural, including land use, institution and human information (figure 5.) (Stephenson 2011: p. 6).

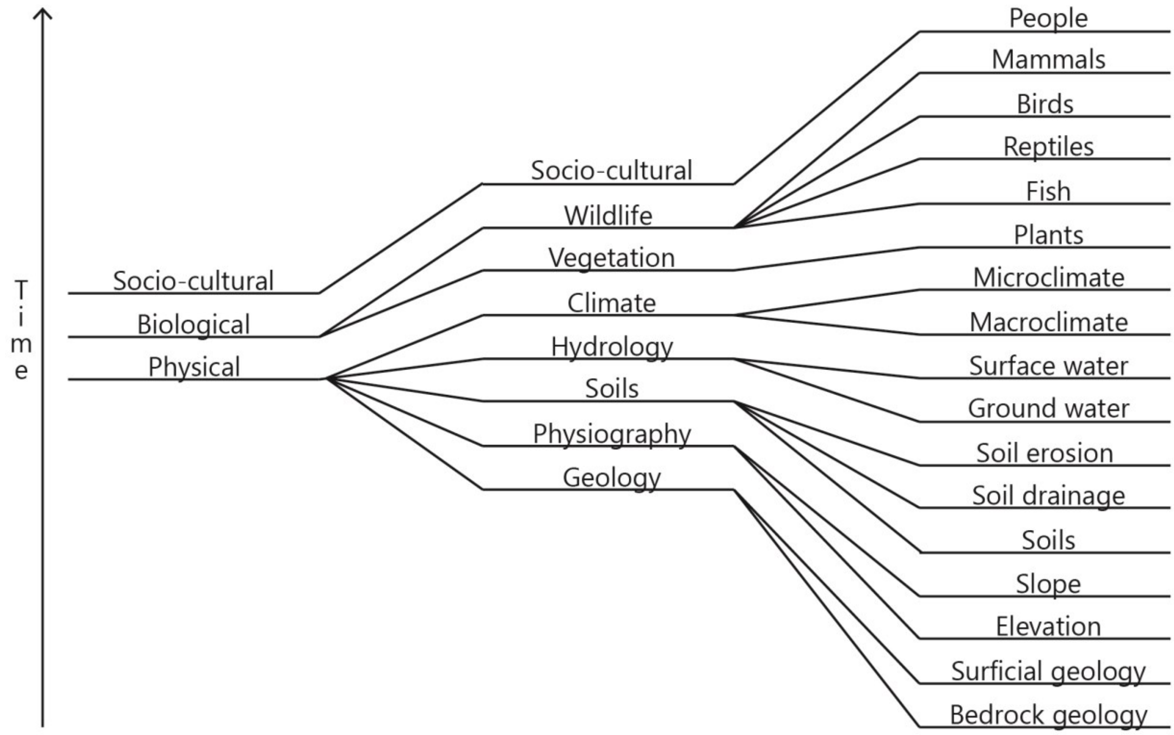

Figure 5. *A layer-cake model illustrates the abiotic, biotic and cultural elements in the landscape* (Ndubisi, 2014, p. 238)

The ABC strategy dissects a research area into four levels of data integration (Ndubisi 2003: p. 238; Stephenson 2011, p. 8–11):

- Level I - Raw Data
- Level II - Environmental Significance and Environmental Constraints
- Level III - Summary Maps: abiotic, biotic and cultural
- Level IV - All the features and their areas of protection

Level 1 is the recognition and mapping of raw data of abiotic, biotic and cultural features in the research area; in the process on level 2, the gathered data would be shown with constraints and values in order to show the significance of local features and environmentally sensitive areas; level 3 is a conclusion map that divides gathered data into abiotic, biotic and cultural significance maps; level 4 involves all the information gathered from previous levels and when compared to policies and management instructions modifications can be stated in the current management (Ndubisi 2003).

The ABC method is a summary of all the values and limitations of the area. It gathers together all the maps and data about the features on it, then categorises the data and shows visually where the most suitable areas are for future development. It is an excluding method – it excludes all the features in the landscape that are in some ways valuable or constrained. Detailed recognition of existing features is not considered. The method is suitable for a general assessment of the constraints and values of the research area.

1.2 Ecosystem services

1.2.1 General definition of ecosystem services

Ecosystem services are the benefits people derive from ecosystems (MEA 2003). Ecosystem services can be defined by three terms that ecosystem services represent: benefits, flows and goods. Benefits are advantages or profits that people obtain from nature, flows of the ecosystem are the supply of profits produced by natural systems and goods represent the physical and other tangible elements from ecosystems (Everard 2017: p. 24).

The Millennium Ecosystem Assessment (MEA) categorises ecosystem services into four different categories: "*provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth*" (MEA 2003).

1.2.2 Assessing and mapping methods for ecosystem services

1.2.2.1 Common International Classification of Ecosystem Services

Common International Classification of Ecosystem Services (CICES) hierarchical classification system is used to measure, account for, organize and assess ecosystem services (Haines-Young, Potschin 2018). Classification system also includes the main Service Providing Units (SPU) (Maes *et al.* 2016) for linking the smallest unit at the desired scale that directly provides Ecosystem Services (Bio-Protection Research Centre 2015). By mapping all the SPUs in the research area ecosystem services linked to the SPUs can be located and identified (table 1).

Table 1. *CICES classification table with ecosystem services and service providing units* cited from Maes *et al.* 2016: p. 83.

CICES Section	**CICES Class**	**Urban ecosystem service**	**Service Providing Units (SPU)**	**Demand**
Provisioning	Cultivated crops,	Vegetable produced by urban allotments and commuting zones	Crop fields, fruit trees, private and public gardens	Consumption
	Surface water for drinking	Water	Watershed	
	Groundwater for drinking			
	Surface water for non-drinking purposes			
	Groundwater for non-drinking purposes			
Regulation	Filtration/ sequestration/ Storage/accumulation by ecosystems	Regulation of air quality by urban trees and forests	Forests, shrubland	Risk of exposure to pollutant concentration beyond thresholds
	Global climate regulation by reduction of greenhouse gas concentration	Climate regulation by reduction of CO_2	Vegetation, soil	
	Micro and regular climate regulation	Urban temperature regulation	Forests, trees, shrubs, herbs, lawns, wetlands, waterbodies	Risk of exposure to high temperatures
	Mediation of smell/noise/visual impacts	Noise mitigated by urban vegetation	Forests, trees, shrubs, vegetated surfaces	Risk of exposure to noise

	Hydrological cycle of water flow maintenance	Water flow regulation and runoff mitigation	Threes, shrubs, vegetated and permeable areas	Risk for flood sensitive areas or land use
	Pollination and seed dispersal	Insect pollination	Crop fields, fruit trees, private and public gardens	Dependency on insect pollination
Cultural	Physical use of land/seascapes in different environmental settings	Nature-based recreation	Parks, gardens, forests, trees, agricultural areas in the commuting zone, wetlands, water bodies, waterways, Natura 2000 sites	Preference; potential and direct use
	Scientific	Nature-based education		
	Educational			
	Heritage, cultural			

1.2.2.2 Urban green infrastructure planning - GREEN SURGE

"The definition of urban green infrastructure (UGI) planning in the Green Surge guidebook for practitioners is stated as a strategic planning method that aims to develop green and blue networks in urban areas that are designed and managed to deliver a wide range of ecosystem services and other benefits at all spatial scale" (Hansen *et al.*, 2017, p. 3). Including all the processes, approaches and policy themes that formulate the principles of UGI, which then adopted to a specific site, can promote, maintain and enhance the quality of life in resource-efficient, compact and climate-resilient cities (Davies, Lafortezza 2017).

Green SURGE project has developed a typology system that consists of green space elements which are divided into 8 groups that are linked to scientific evidence on their corresponding ecosystem services (table 2.) (Hansen *et al.* 2017). Typology helps to understand the functional connections between green spaces and built environment.

Table 2. *Green SURGE green space typology cited from Maes et al. 2016.*

Category	**Green space element**
Building greens	Balcony green
	Ground-based green wall
	Facade-bound green wall
	Extensive green roof
	Intensive green roof
	Atrium
Private, commercial, industrial, institutional UGS and UGS connected to grey infrastructures	Bioswale
	Tree alley and street tree, hedge
	Street green and green verge
	House garden
	Railroad bank
	Green playground, school ground
Riverbank green	Riverbank green
Parks and recreation	Large urban park
	Historical park/garden
	Zoological garden
	Neighbourhood green space
	Institutional green space
	Cemetery and churchyard
	Green sport facility
	Camping area
Allotments and community gardens	Allotment
	Community garden
Agricultural land	Arable land
	Grassland
	Tree meadow/orchard
	Biofuel production/agroforestry
	Horticulture
Natural, semi-natural and feral areas	Forest (remnant woodland, managed forests, mixed forms)
	Shrublands
	Abandoned, ruderal and derelict area
	Rocks
	Sand dunes

	Sandpit, quarry, open cast mine
	Wetland, bog, fen, marsh
Blue spaces	Lake, pond
	River, stream
	Dry riverbed, rambla
	Canal
	Estuary
	Delta
	Seacoast

The Green SURGE urban green infrastructure planning guide is proposing a method that can address four different urban challenges:

1. Adapting to climate change
2. Protecting biodiversity
3. Promoting green economy
4. Increasing social cohesion

That can be conquered by four main principles:

1. Green-grey integration
2. Connectivity
3. Multifunctionality
4. Social inclusion

that are expressed in practical actions on the site: assessment, plan development, stakeholder engagement, implementation (Hansen *et al.* 2017). Depending on the site, challenges and principles could vary.

1.3 Recreation opportunities

1.3.1 Recreation opportunities as an ecosystem service

"*Cultural ecosystem services are explained as the non-material benefits people receive from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience that are an important part of human well-being*" (Martin *et al.* 2016: p. 26). Classified as a cultural ecosystem service, recreation opportunities are one of the most noted ecosystem service near coastal areas (Nahuelhual *et al.* 2017: p. 212). Recreation is a complex ecosystem service that needs to approached so that both environmental and socio-economical perspectives are taken into account (Kulczyk *et al.* 2018: p. 1). Negative effect on ecologically sensitive areas (nature protection sites, wetlands, fragile soils and vegetation, protected species) can be avoided by not including these areas in the planning or by applying measures to prevent the harm (Bell 1997: p. 15).

1.3.2 Recreation opportunity as a public asset

"In this century, we are facing a different kind of threat to public space - not one of disuse, but of patterns of design, management and systems of ownership that reduce diversity" (Low 2006: p. 44). Privatisation of public coastal areas is one of the main reasons for fragmented green connections and recreational routes. Detailed plans are often including public green areas in the proposal, in reality these green areas offer *"an experience of exclusion"* (Keul 2015: p.

49) by applied restrictions, policies and management: prohibiting signs, separating fences etc.

"*The degree of publicness is related to the degree of appropriation: how individual people can make use of space to meet their daily needs*" (Leclercq 2018: p. 23). When people feel that they can use the facilities that public recreational areas offer, they feel welcomed and included in the local society.

1.3.3 ROS – Recreational Opportunity Spectrum

The Recreation Opportunity Spectrum (ROS) is a tool used as a guide for planning recreational areas (Joyce, Sutton 2009). First introduced in the United States, ROS was used to provide a framework for (United States Department of Agriculture, 1982: 9):

- *"Imposing the outdoor recreational management objectives to certain areas*
- *Trade-off analysis for obtainable recreational opportunities due to the modification of the characteristic setting by other proposed management actions*
- *Monitoring output according to established standards for experience and opportunities settings*
- *Setting up specific management objectives and standards for future project plans"*

In addition to the activities, ROS also includes the quality of a specific site in which the activities take place (Bell 1997: p. 18). The approach is dividing the possible recreational experiences into spectrum and matching them with the setting of the site: one end of the spectrum with more rural setting proceeding towards more urban setting of the site

(Lindholst *et al.* 2015: p. 73). The spectrum is divided into six classes and each of them includes three components: the activities most suitable, the character of the setting and a possible experience to feel (Bell 1997: p. 19).

Summarised categories by Simon Bell (1997: p. 19):

1. **Primitive (P)**: large natural areas, unaffected by human activity, possible feeling of solitude, remote areas, that require independent actions and skills.
2. **Semi-primitive, non-motorised (SP – NM):** smaller natural areas, reduced feeling of solitude, minimal site control, similar activities as in the primitive category.
3. **Semi-primitive, motorized (SP – M):** similar to the previous category with additional motorized activities, the quality of solitude may be affected due to the possible access of motorized vehicles.
4. **Roaded, natural (R – N)**: natural area with signs of managements, more use due to the built in roads for easier access, experience of solitude may be combined with social interaction, requirement for independence is reduced in importance.
5. **Rural (R):** human influence is starting to dominate over the natural character, area is more maintained and equipped with facilities and there is more chance to socialize.
6. **Urban (U):** widest range of activities is possible, setting is dominated by human influences, area is designed and managed, equipped with many facilities and feeling of solitude is made complicated but still can be achieved by incorporating intelligent design.

1.4 Similar inspirational case studies

When EU launched the Green Infrastructure (GI) Strategy in 2013 (Europarc Federation 2018) many EU countries started to engage the strategy in their cities. Three case studies are introduced to show inspirational examples of successful projects.

A case study was done in the metropolitan area of Rome, Italy, to assess the biodiversity and ecosystem services in the area. The project was done during the EU GI strategy and it includes indicator framework in MAES approach and biodiversity conservation. Final result incorporated forest restoration, tree planting with providing ecosystem services as stated by the states of different indicators (Capotorti *et al.* 2018: p. 7). Result was meant to include both environmental and socio-economic (Capotorti *et al.* 2018: p. 7) benefits in the proposal and actions.

Second inspirational case study was done in Vitoria-Gasteiz , Spain: "*The Green Belt: 25 years working for a multifunctional urban green infrastructure*" (Environmental Studies Centre 2012). After 25 years of hard work it was possible to re-establish the positive state of landscapes and ecology of many fragmented areas (figure 6.). "*Besides its aesthetic and ornamental function and as well as being space for leisure pursuits and social relations, it plays a fundamental role in improving the environmental quality of the urban milieu, contributing to an improvement in the general habitability of the city and providing relevant ecosystem services to the city and its inhabitants*" (Europarc Federation 2018).

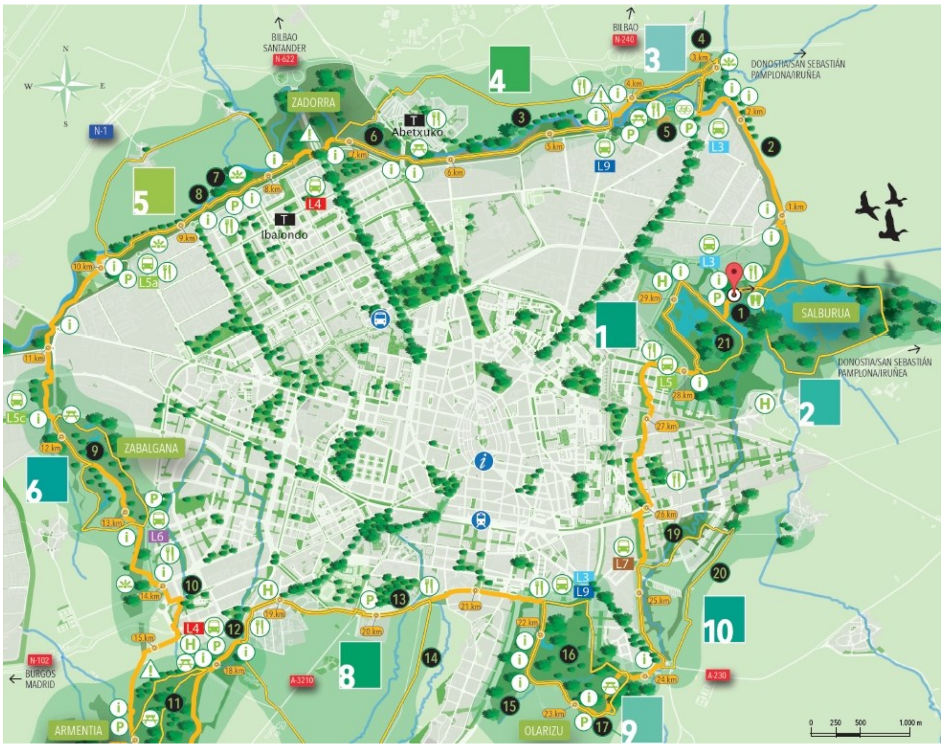

Figure 6. *Green belt map of Vitoria-Gasteiz* (Europarc Federation 2018)

Third example is from the metropolitan area of Barcelona, Spain. Barcelona has created an inspiration document for biodiversity and green infrastructure planning: Barcelona green infrastructure and biodiversity plan for 2020. The plan is coordinated with the EU strategic planning for 2020. Social and environmental institutions and experts from universities and research centre were included in process for coming up with the shared diagnosis, risks and challenges an eventually a vision, goals or actions (Ajuntament de Barcelona 2013).

Master's thesis done by Tuuli Veersalu in 2009 in introducing an interesting approach by converting the county wide green planning into more detailed scale – scale of Viimsi local municipality near Tallinn. Other objectives were to develop green network planning in the level of a local municipality and to open up the problematic subjects of green network planning on a wider scale (Veersalu 2009). Inspirational was the fact that this master thesis had a practical outcome of being a part of Viimsi municipality thematic plan about *milieu values and green areas.*

Master's thesis done by Kristofer Soop in 2014 offers a concept for planning sea-recreation possibilities based on Tallinn coastal areas. Objective of the concept was to create a structured model for organising sea-recreation possibilities and that the concept could be adaptable to different areas (Soop 2014). It was Interesting to read about a different approach on a similar area. "Access to the sea needs to be a public asset" is an inspirational principal that needs to be pursued in the future.

2 METHODOLOGY

2.1 Identification of the study area

The study area was selected for further research during a design project done in Kopliranna coastal area, in Kopli, Northern Tallinn. Positioning the local green infrastructure in Kopli district was a part of the analysis of the project. It turned out that the green infrastructure in the district was fragmented and many green areas acted as individual islands. The scale was expanded and the study area was positioned northwest of Tallinn city centre, in the North-Tallinn district, in Tallinn – the capital city of the Republic of Estonia (figure 7.). Three main hubs were located – Paljassaare Nature Reserve in the North, green area around Kaelajärv Lake in the centre and Merimetsa Greenland Conservation Area in the South. Smaller sites were located in Kopli and Pelguranna settlements.

The research area covers Kopli, Paljassaare, Pelguranna and Merimetsa settlements that are located in the northern part of North-Tallinn district and at the beginning of Kopli and Paljassaare peninsula. The area is surrounded by Kopli bay from the West, Paljassaare bay from the North and Gulf of Tallinn from the East. Pelguranna, Sitsi and Karjamaa settlements are bordering the study area from the South (figure 8.). Population density in Northern Tallinn is 3930 ppl/km^2, population number in Kopli is 6953, in Paljassaare 488, in Pelguranna 15007 and in Sitsi 3813 (Tallinn Statistic Atlas 2018).

Figure 7. *City districts of Tallinn and the research area – Northern Tallinn district, Kopli and Paljassaare peninsulas*

Figure 8. *Study area in Northern Tallinn*

2.2 General framework

After identifying the research area multiple sources were reviewed to filter out the most suitable method for proceeding with the work. Green infrastructure as a term was researched and assessed, mapping and planning methods were reviewed and referred to. The EU strategy for 2020 offered many comprehensive reports on how to assess and map ecosystem services and their conditions for future green infrastructure planning urban environments. Following these reports and multiple public databases a fairly comprehensive amount of ecological indicators could be collected about Northern Tallinn. Recreational indicators, as being a field of interest as well, were collected and paralleled with the ecological indicators.

The DPSIR approach is used as a diagnostic and structuring tool for the assessment of the ecological as well as recreational indicators of Kopli and Paljassaare green infrastructure. Approach has five steps: 1) interpretation of drivers; 2) assessment of pressures; 3) assessment of states; 4) assessment of impacts, and 5) proposal of responses (figure 9.).

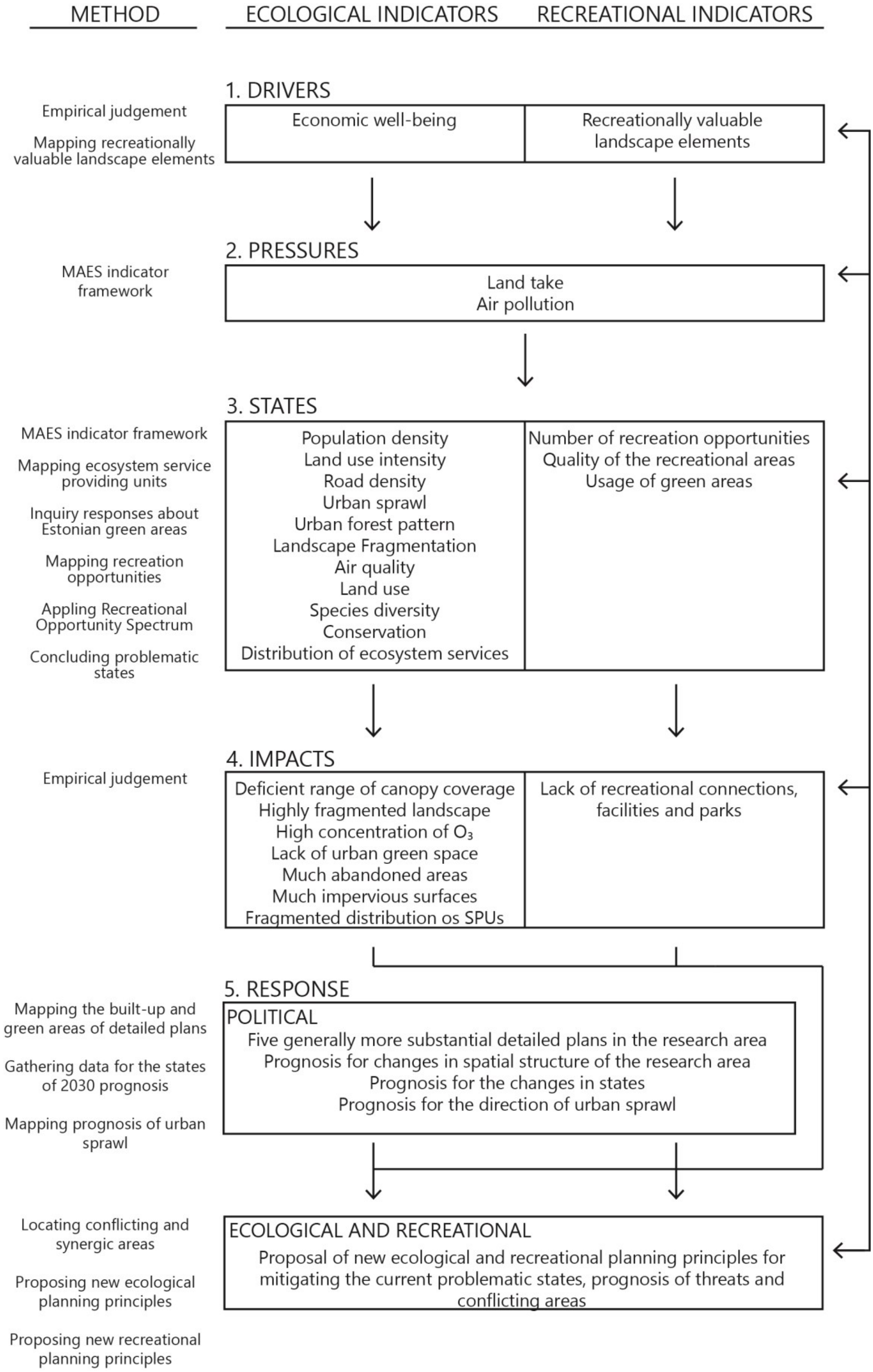

Figure 9. *Five stages of the DPSIR approach*

1. **Interpretation of drivers:** Current drivers in the area were assessed in an empirical level. Economic well-being drives people to peri-urban areas close to the City Centre that have not been renewed yet. All recreationally valuable land units and their buffer zones were mapped to locate theoretically attractive areas and drivers for recreation. The overlap of the buffer zones will help to locate recreationally most valuable areas.

2. **Assessment of pressures:** An indicator framework was followed to determine current pressures in ecosystem conditions.

3. **Assessment of states:**

   3.1 Ecological states: For assessing the ecosystem conditions the structure of an indicator framework from MAES fourth report was followed (Maes *et al.* 2016). The evaluation of the conditions has to be done according to what is considered to be a good condition for humans living in urban biodiversity – good quality of air, water, a sustainable reserve of ecosystem services (Maes *et al.* 2018). The key indicators are included in the evaluation of the condition. States of the ecosystem conditions were gathered using public reports, public statistical databases, and online map applications. Targets and strategies were included as a reference to comprehend the normative. The distribution of ecosystem services were mapped by linking ecosystem services to service providing units to assess the current state and distribution of ecosystem services.

   3.2 Recreational states: Current state of the recreation opportunities were assessed and mapped (facilities, health trails and parks) by doing site visits in Northern Tallinn. In order to assess current state of the quality of the recreational areas, the Recreational Opportunity Spectrum (ROS) was applied. Current state of the usage of green areas was issued from a mapping inquiry about the usage of green areas in nine Estonian towns.

4. **Interpretation of impacts:** Number impacts are interpreted in an empirical level – possible outcome because of the occurred changes in the states.

5. **Proposal of responses:**

   5.1. Political response: Five detailed plans were considered as a political response. Detailed plans that are considered in this political proposal are big scale, initiated, in draft or established. Built-up and green areas of the detailed plans were mapped to visualise the spatial changes in a larger scale. Data about prognosis of 2030 is gathered from the explanatory notes. Number of new inhabitants were mapped to locate the direction of urban sprawl.

   5.2 Response based on green infrastructure planning principles and mapping: by overlapping ecological and recreational layer with the layer of political response it was possible to locate the conflicting and synergic areas. First, necessity for ecological and recreational connections and potential areas for new recreational opportunities were located. Then, these areas were overlapped with areas that carry sensitive service providing units to guarantee the protection of sensitive land units. The outcome was then overlapped with detailed plans introduces as a political response to locate the conflicting and synergic areas. Planning principles are phrased to mitigate the problematic conditions that emerged from the studied states of the ecosystems and recreational opportunities in Kopli and Paljassaare district; and to eliminate the threats of the political response according to the prognosis for 2030. The response is divided into two sets of planning principles – ecological and recreational planning principles.

3 RESULTS

3.1 Interpretation of drivers

Economic well-being – bigger incomes, economic growth, gentrification, increased popularity of the area and closeness to the sea are the triggers that drive people to peri-urban areas close to the City Centre that have not been renewed yet.

Land units that are considered recreationally valuable: rapids, bigger rocks, slopes, shores of internal waters, streams, sea shore, piers, green areas, memorials, monuments, glade grasslands, trees, forests, light beacons (figure 10.). Each land unit or element has a buffer zone with 25 m radius. By assessing the recreationally valuable land units and buffer zones, it could be claimed that more overlaps of the buffer zones are located near the seaside, green areas near the coast and parks. Many overlaps occur at the western coast of Paljassaare peninsula where there are a large glade grassland, small streams and the coastline.

Figure 10. *Recreationally valuable land units and buffer zones mapped in the green layer* (Vassiljev 2018)

3.2 Assessment of pressures

An indicator framework was followed to determine current pressures in ecosystem conditions (table 3.). Land take is a pressure for ecosystems because parts of natural land is transformed into artificial land. Air quality has a direct impact on human health and species diversity so it is important to measure the condition of specific particles.

Table 3. *An indicator framework for assessing the condition of pressures in urban ecosystems cited from* Maes *et al.* 2016.

Pressures on urban ecosystems	
Class	**Indicator**
Land take	Percent of built-up area (%)
Air pollution	NO_2 annual mean in 2014
	PM_{10} annual mean in 2014
	93.2 percentile of O_3 maximum daily 8-hours mean in 2014

3.3 Assessment of states

3.3.1 Ecological states

Results about current conditions of states in urban ecosystems is gathered using the public statistical databases about Northern Tallinn or Tallinn (Tallinn Statistic Atlas 2018), Estonian Maa-amet map application (Maa-amet 2018), Copernicus Pan-European high resolution layers (© European Union 2018), the report about landscape fragmentation in Europe

(European Environmental Agency 2012), the report on air quality monitoring in Estonia 2014 (Saare *et al.* 2015), land use data from the report about CO_2 emissions in Tallinn (Keskkonnaamet 2018), and public reports of avifauna of green areas (NGO Tallinn Bird Club 2006) (table 4.).

In order to assess the condition of gathered data, different strategies and targets were collected for reference: European average standards of land use from the article about urban forestry in Europe (Konijnendijk 2003), air quality guidelines from Europe Air Quality Report of 2017 (European Environment Agency 2017), land use from the general plan of Northern Tallinn (Tallinn City Planning Office 2017) and condition of bird species from the report about changes in Tallinn avifauna (Uustal, Peterson 2006).

The state of the built infrastructure is defined as preferably stable and not increasing in area. It could be claimed that canopy coverage of Northern Tallinn could cover larger areas. The indicator of landscape fragmentation shows that the landscape of Northern Tallinn is highly fragmented. When comparing the current conditions to the reference data it could be stated that current concentration of air pollution is not significantly high. The concentration of NO_2 and PM_{10} annual mean in 2014 was rather low compared to the standards proposed in the EU Air Quality Report of 2017. The concentration of O_3 maximum daily 8-hours mean in 2014 was over the normative level according to the EU Air Quality Report.

Assessment of the land use indicators demonstrates that Northern Tallinn could have more urban green spaces, less abandoned areas and impervious surfaces. Proportion of natural green areas is fairly high. The existence and high percentage of protected areas is a positive indicator. If the number of nesting bird species and species under protection stays stable, then condition of the state is considered positive.

Table 4. An indicator framework for assessing the condition of states in urban ecosystems

State indicators of urban ecosystems – built infrastructure			
Class	**Indicator**	**Current Data**	**Reference data**
Population density	Number of inhabitants per km^2	3930 ppl/km^2 *	Not defined, preferably slowing the increase
Land use intensity	Artificial area per inhabitant	~138,8 m^2	Not defined, preferably slowing the increase
Road density	Length of the roads per km^2	~150 m	Not defined, preferably slowing the increase
Urban sprawl	Percent of built-up area (%)	55 % *	Not defined, preferably slowing the increase
State indicators of urban ecosystems – green infrastructure			
Class	**Indicator**	**Current Data**	**Reference data**
Urban forest pattern	Canopy coverage (km^2, %)	4, 5 km^2 (29%)	The European average is 31%
Landscape Fragmentation	Landscape fragmentation per 1 km^2 grid in 2009 (Mesh density pixel)	25-50 meshes per 1 km^2 (S_{eff})	The European Average number is 1–10
Air quality	Concentration of:		
	NO_2 annual mean in 2014	≤ 13,5 μg/m^3	≤ 40 μg/m^3
	PM_{10} annual mean in 2014	≤ 13,2 μg/m^3	≤ 20 μg/m^3

	93.2 percentile of O_3 maximum daily 8-hours mean in 2014	≤ 107 µg/m³	100 µg/m³
State indicators related to the proportion of green and built infrastructures			
Class	**Indicator**	**Current Data**	**Reference data**
Land use	Proportion of urban green space (%)	24 %	European average is 30%
	Proportion of natural areas (%)	45 %	20 %
	Proportion of protected areas (%)	12 %	Not defined, preferably existing
	Proportion of built abandoned areas (%)	2 %	0 %
	Proportion of impervious surface (%)	50 %	Not defined, preferably slowing the increase
State indicators of urban biodiversity			
Class	**Indicator**	**Current Data**	**Reference data**
Species diversity	Number of nesting bird species per km²	226 per km²	Stable number
Conservation	Number of species under protection per km²	35 per km²	Stable number

*Colour coding shows the poor ecosystem conditions in red and good in green. Conditions in a normal state are coloured yellow

Urban ecosystem services are paralleled with physical service providing land units (SPUs). SPUs were located and mapped in Northern Tallinn (table 5.) (figure 11.). By displaying the distribution of services, one layer of current state of the green infrastructure is visualised and the fragmentation can be assessed more closely.

Table 5. *Urban ecosystem services linked with service providing units (SPUs) extracted from* Maes *et al.* 2016: p. 83.

Urban ecosystem service	**Service providing units (SPUs)**
Drinking water	Watershed
Regulation of air quality by urban trees and forests	Forests, scrublands
Climate regulation by reduction of CO_2	Vegetation, soil
Urban temperature regulation	Forests, trees, shrubs, herbs, lawns, wetlands, waterbodies
Noise mitigated by urban vegetation	Forests, trees, shrubs, vegetated surfaces
Water flow regulation and runoff mitigation	Threes, shrubs, vegetated and permeable areas
Insect pollination	Crop fields, fruit trees, private and public gardens
Nature-based recreation	Parks, gardens, forests, trees, agricultural areas in the commuting zone, wetlands, water bodies, waterways, Natura 2000 sites
Nature-based education	

Figure 11. *Mapped service providing units (SPUs)*

3.3.2 Recreational states

The current recreation opportunities are represented in the current number of recreational facilities (equipment, health trails and parks). There are two official nature trails – Merimetsa and Paljassaare Nature Reserve health trails and two paved walking trails – Pelguranna and Kopli walking trails. There are four parks in the western part of the research area: Süsta Park, Kase Park, Stroomi Beach Park and Kopli Cemetery Park. Pikakari Beach is located at the end of Paljassaare peninsula, next to the Nature Reserve. Süsta and Kase Parks are equipped with a walking trail; Stroomi Beach Park is equipped with paved walking trails, ballgame squares, outdoor gyms, a cafeteria, changing booths, lockers, showers, picnicking and grilling places, playgrounds, biking trails, trash bins, benches, information stands and lighting; Kopli Cemetery Park is equipped with playgrounds, paved walking trails, benches, trash bins, lighting, information stands and fountain memorial. Paljassaare Nature Reserve is equipped with watch towers, walking trails, a trash bin and information stands. Paljassaare beach is equipped with changing booths, a volleyball court, a playground, benches, a boardwalk, trash bins and toilets.

A map was compiled to visualise the current recreational opportunities (figure 12.). The paved walking trails are well connected between Merimetsa area and Süsta Park. There are no official connections to the northern coastal area and Paljassaare Nature Reserve trail. Paljassaare peninsula is lacking recreation facilities, health trails and parks. Most of the recreation facilities are located in the western park of Northern Tallinn – Stroomi Beach Park and Kopli Cemetery Park.

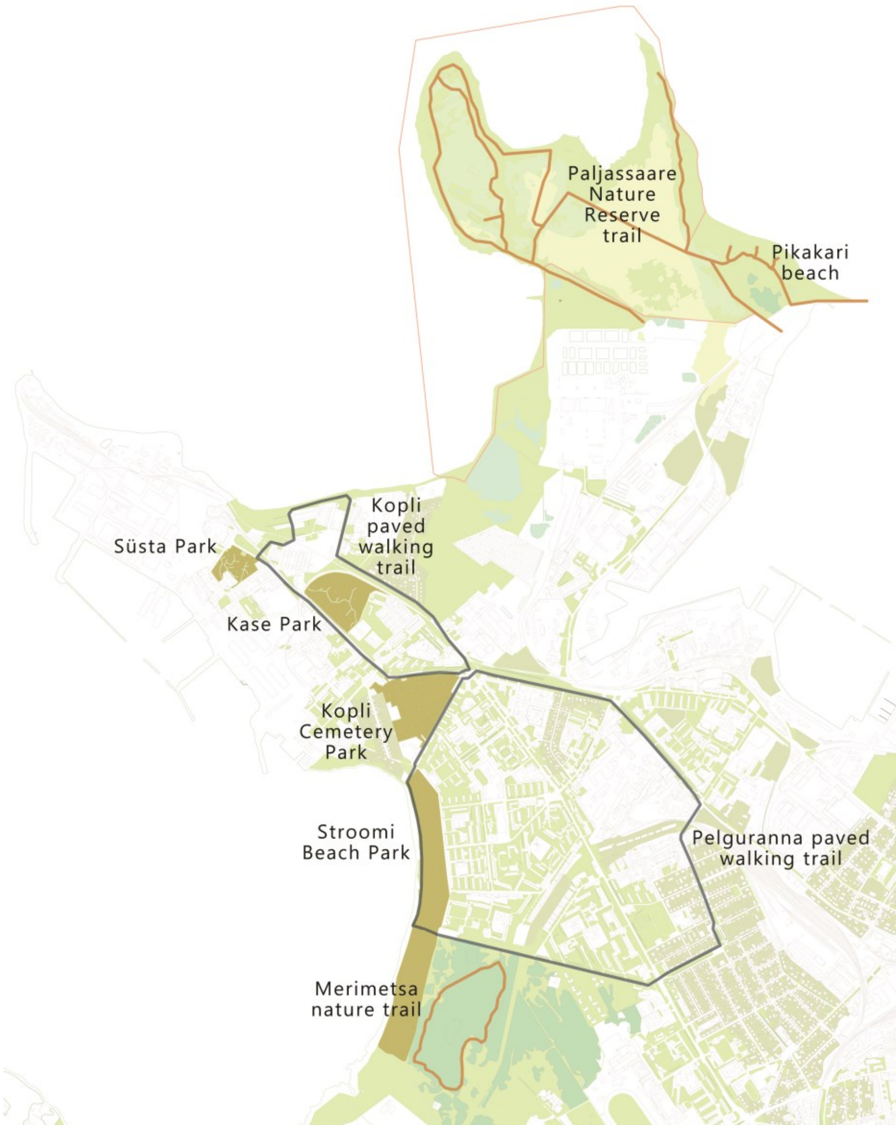

Figure 12. Recreation opportunities in Northern Tallinn

In order to assess the current state of the quality of the recreational areas, the Recreational Opportunity Spectrum (ROS) was applied. According to ROS, four types of experiences are represented in the recreation areas of the study area: semi-primitive – non-motorised, semi-primitive – motorised, rural and urban (figure 13).

Figure 13. *Represented ROS classes in the study area*

Results about current use of green areas were collected from an inquiry held in 2015 to address people who use green areas in nine different Estonian towns. The purpose of the inquiry was to map the habits of urban residents in green areas and explain how people relate to a specific green area and its condition. Answers were collected from people who use green areas in Tallinn, Tartu, Narva, Haapsalu, Pärnu, Kuressaare, Rakvere, Viljandi and Võru (Niin 2015).

From the database of Tallinn, results about Northern Tallinn green areas were extracted. 20 people marked their favourite and 46 people marked their recently used green area in Põhja-Tallinn. Quantitative results could be extracted from the database: number of location points that are used by people.

Quantitative results could be visualised as heat map – darker areas show the locations of which people had marked their favourite or recently used (figure 14.). Most intensive use of green areas is located near Stroomi beach and Merimetsa nature trail. People also use Kopli Cemetery Park and Paljassaare Nature Reserve and Pikakari beach. It could be stated that people use areas that are equipped and have more facilities.

Figure 14. *Heat map of the locations people had marked 'recently used' or 'favourite'.*

3.3.3 Conclusion of problematic conditions

Based on previous assessments on chapters 3.3.1 and 3.3.2 most problematic conditions of the current state in ecosystem services and recreational opportunities are concluded in current chapter according to the reference data:

- Deficient range of canopy coverage
- Highly fragmented landscape and green infrastructure
- Concentration of O_3 exceeding the level of normative
- Lack of urban green space
- Many built abandoned areas
- Many impervious surfaces
- Distribution of SPUs is fragmented in the central part of Northern Tallinn
- Lack of recreational connections, facilities and parks that are linked to Paljassaare peninsula green areas

3.4 Interpretation of impacts

Economic growth, urban sprawl and air pollutants apply pressure to the environment. Pressures cause change in the states of the ecosystem conditions. Ecosystem provides services that the society depends and benefits from. Changes in the states of ecological conditions cause change in ecosystem services and will therefore have an impact on human health and ecosystems.

Possible changes caused by pressures can cause impacts on states. States that are currently in a more problematic condition are in the most vulnerable for pressures. Negative changes in vulnerable states like: canopy coverage, landscape fragmentation, concentration of O_3, urban green spaces, abandoned areas, impervious surfaces, distribution of SPUs can cause even bigger impacts in the future.

3.5 Proposal of responses

3.5.1 Political response – prognosis for 2030

Five generally more substantial detailed plans are in process or already established in Kopli and Paljassaare district. The data about the prognosis about new number of inhabitants, additional size of built-up area and the size planned green spaces is brought out in the table 6.

1. Ecobay – Detailed plan of Paljassaare cross 16 and surrounding areas (Initiated 19.07.2010)
2. Paljassaare port – Detailed plan of 16 lots in Paljassaare port and surrounding areas (Initiated 20.04.2009)
3. Kopli lines – Detailed plan of Kopli lines and surrounding areas (Established 02.05.2009)
4. Kopliranna – Detailed plan of Sirbi, Kopliranna, Vasara street and coastal area (Partly established 07.09.2017)

5. Paljassaare artificial islands – Detailed plan of Paljassaare artificial islands (Accepted 18.10.2017)

Table 6. *Prognosis about new detailed plans for the year 2030*

Detailed plan	**Inhabitant (ppl)**	**Built up area (km^2)**	**Urban green space (km^2)**
Ecobay	5500	0,51	0,07
Paljassaare port	7000	0,04	0,05
Kopli lines	1820	0,047	0,06
Kopliranna	545	0,035	0,04
Paljassaare artificial islands	225	0,03	0,07
Sum	**15090**	**0,662**	**0,29**
Currently in Northern Tallinn	**75634**	**9,002**	**4,02**

By mapping the green areas projected in mentioned detailed plans it is possible to visualise the emphasis of green infrastructure planning being a small part in the planning process (figure 15.). Most of the initiated detailed plans have green areas in the name of "beach promenade" that is considered in the coastal construction exclusion zone – the green connections in the inner land are deemed unnecessary.

Planned residential areas need to have green areas and promenades that are connected to the existing green network creating recreational opportunities not only by the coast line but also through inner land. These recreational areas need to have a public access and atmosphere – people feel that they can use these spaces to fulfil their everyday necessities. Threat lies in the planning methods of green areas according to current detailed plans – disconnected recreational routes, lack of opportunities and the feeling of exclusion.

Figure 15. *Detailed plans of emphasised planned green areas Northern Tallinn*

Table 7. Prognosis for states of the year 2030

State indicators of urban ecosystems – built infrastructure		
Class	**Indicator**	**Planned conditions for 2030**
Population density	Number of inhabitants per km^2	~4979 ppl/km^2 *
Land use intensity	Artificial area per inhabitant	~115,9 m^2
Road density	Length of the roads per km^2	Increased
Urban Sprawl	Percent of built-up area (%)	59% *
State indicators of urban ecosystems – green infrastructure		
Class	**Indicator**	**Planned conditions for 2030**
Urban forest pattern	Canopy coverage (km^2, %)	DPs do not influence canopy coverage
Landscape Fragmentation	Landscape fragmentation per 1 km^2 grid in 2009 (Mesh density pixel)	Increasing number of meshes
Air quality	Concentration of:	
	NO_2 annual mean in 2014	More traffic - more emissions
	PM_{10} annual mean in 2014	More traffic – more emissions
	93.2 percentile of O_3 maximum daily 8-hours mean in 2014	More NO_2, more degradation
State indicators related to the proportion of green and built infrastructures		
Class	**Indicator**	**Planned conditions for 2030**
Land use	Proportion of urban green space (%)	28%
	Proportion of natural areas (%)	30 %
	Proportion of protected areas (%)	11 %
	Proportion of built abandoned areas (%)	1 %

	Proportion of impervious surface (%)	55%
State indicators of urban biodiversity		
Class	**Indicator**	**Planned conditions for 2030**
Species diversity	Number of nesting bird species per km²	Unstable due to construction in and near the nature reserves
Conservation	Number of species under protection per km²	Unstable due to construction in and near the nature reserve

Results about the planned conditions of states in Northern Tallinn for 2030 developments are gathered from traffic prognosis report about Paljassaare and Ecobay (Engineering bureau Stratum 2010), explanatory notes of Paljassaare (AS K-projekt 2017b), Ecobay (AS K-projekt 2015), Kopli lines (RAAM Arhitektid OÜ 2009), Meeruse port (AB Korrus 2017), Kopliranna (AS Sweco Project 2009), Paljassaare artificial islands detailed plans (AS K-projekt 2017a), derived from report on air quality monitoring in Estonia 2014 (Saare *et al.* 2015) and the traffic prognosis report about Paljassaare and Ecobay (Engineering bureau Stratum 2010) (table 7.).

Due to planning in the areas that already have an impervious surface, construction of new artificial islands with green areas and due to a great increase in the number of inhabitants per km² the percentage of artificial area per inhabitant decreased by 22,9 m². New detailed plans do not plan to reduce the number of trees in the district – larger woodlands and parks will be preserved and the canopy coverage will remain the same. The percentage of urban green space will increase due to the planning of new parks and gardens. Most of the abandoned areas would be involved in planning urban green spaces. By considering the new developments, the percentage of natural areas would still remain high.

There are also many threats that would occur in the 2030 prognosis scenario. Built up area is still increasing by 4%, the increase in the number of inhabitants per km^2 is by 1049 ppl/km^2 and there is an increase in the length of roads per km^2. Green infrastructure connections are not planned in the detailed plans – the fragmentation is increasing. The Ecobay detailed plan area is overlapping with the Paljassaare nature reserve – decreasing its size. The percentage of impervious surface is increasing. The construction near and in nature reserves and coastal areas makes the number of nesting bird species and the number of species under protection unstable – construction has to be carefully coordinated with the nesting and migration season of the local species.

A heat map was compiled to locate the possible direction of urban sprawl in the area (figure 16.). By comparing two maps it is possible to state that the trends for developments are proceeding in the northern and north-eastern direction. New detailed plans offer housing areas for large number of inhabitants.

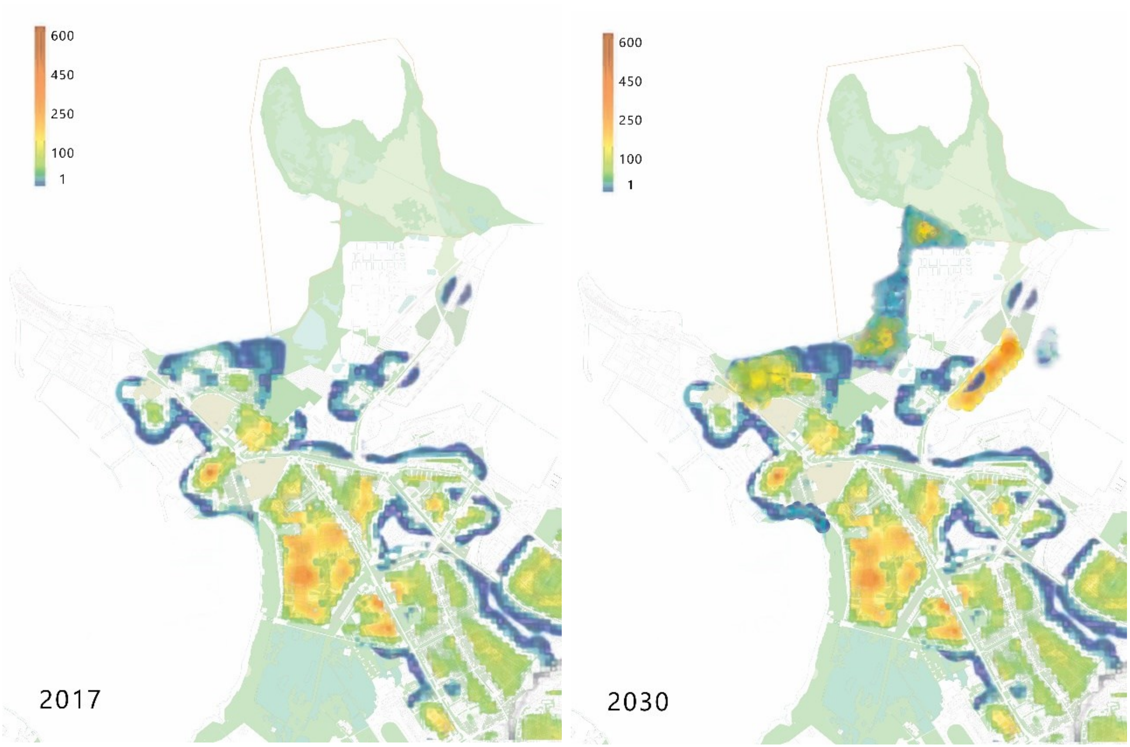

Figure 16. *Current number of inhabitants per 1 ha (Tallinn et al. 2008) and future number of inhabitants per 1 ha (Prognosis for 2030)*

3.5.2 Response based on the green infrastructure planning principles

3.5.2.1 Locating conflicting and synergic areas based on mapped land units

Overlays of different map layers were carried out to bring out the most conflicting and synergic areas of the political response according to the previous results about states.

Firstly, based on distribution of service providing units (SPUs), it is possible to mark areas that need more ecological connection. Connections can be planned in order to meet planning principles of green infrastructure. Linear green connection are often missing from between smaller sites and bigger hubs. Linear green connections can be planned by founding linear parks, planting tree lines (increasing the canopy coverage) and using permeable surfaces (figure 17.) and combining private and semi-private green patches in such way that a joint green corridor is formed.

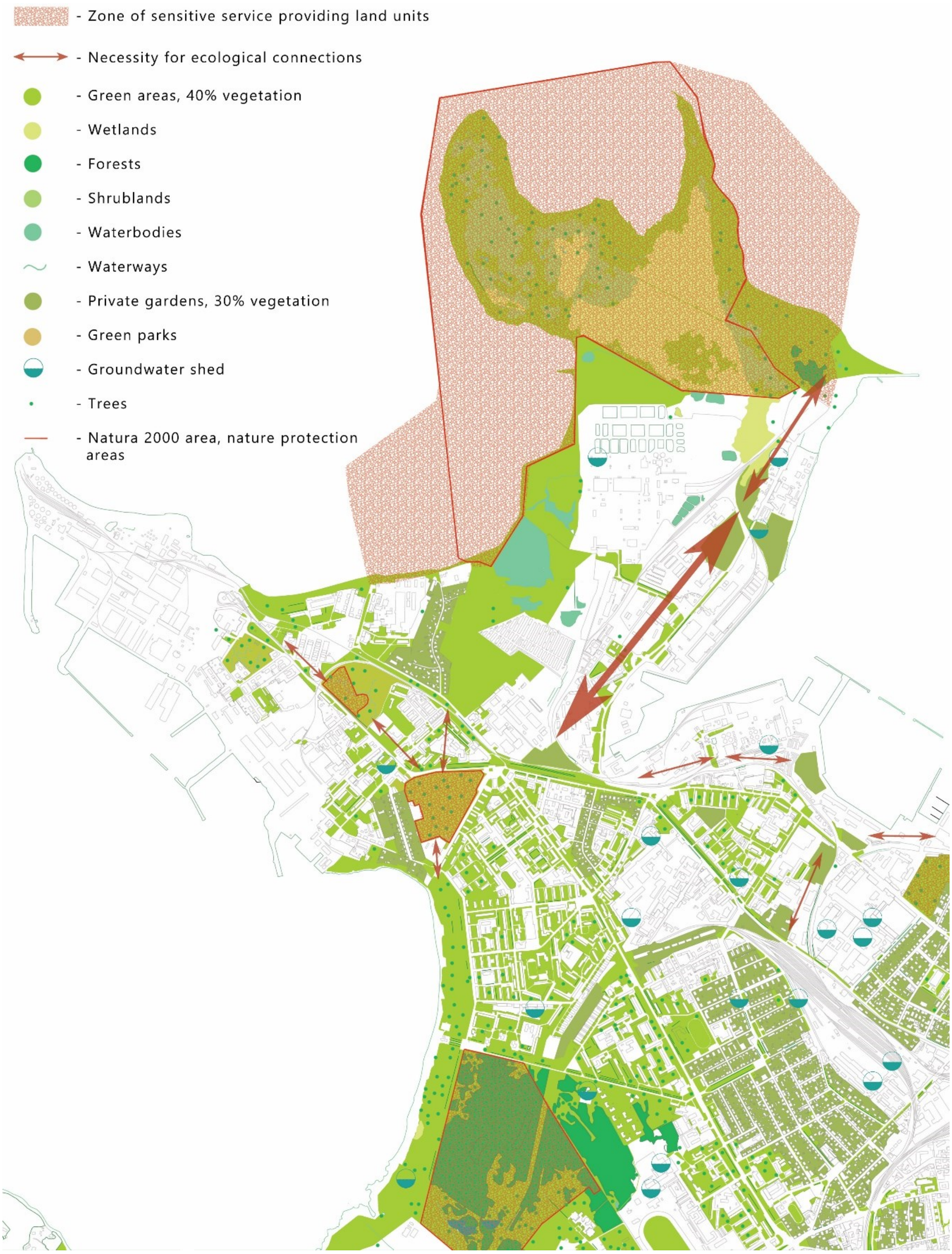

Figure 17. *Mapped service providing units with the necessity for green infrastructure connections*

Secondly, by overlapping layers of recreationally valuable land units, usage of green areas and ROS classes, it is possible to state aspects about the current situation. People are using more recreational areas in urban and semi-primitive – non-motorised ROS classes. The Northern coastline has many valuable land units that many people have not mentioned as used or favourable - there is a big potential for recreational opportunities in those areas. There are no valuable landscape units near the paved walking trails – green infrastructure elements could be planned. In addition to the Northern coastline there are many recreationally valuable land units in the areas that are not actively used – eastern coastline of Paljassaare peninsula, upper part of western coastline also called the Kopliranna beach. According to the recreational planning principles and map analysis, areas that are potential for new recreation opportunities and areas where there is necessity for better recreational connection were located (figure 18.).

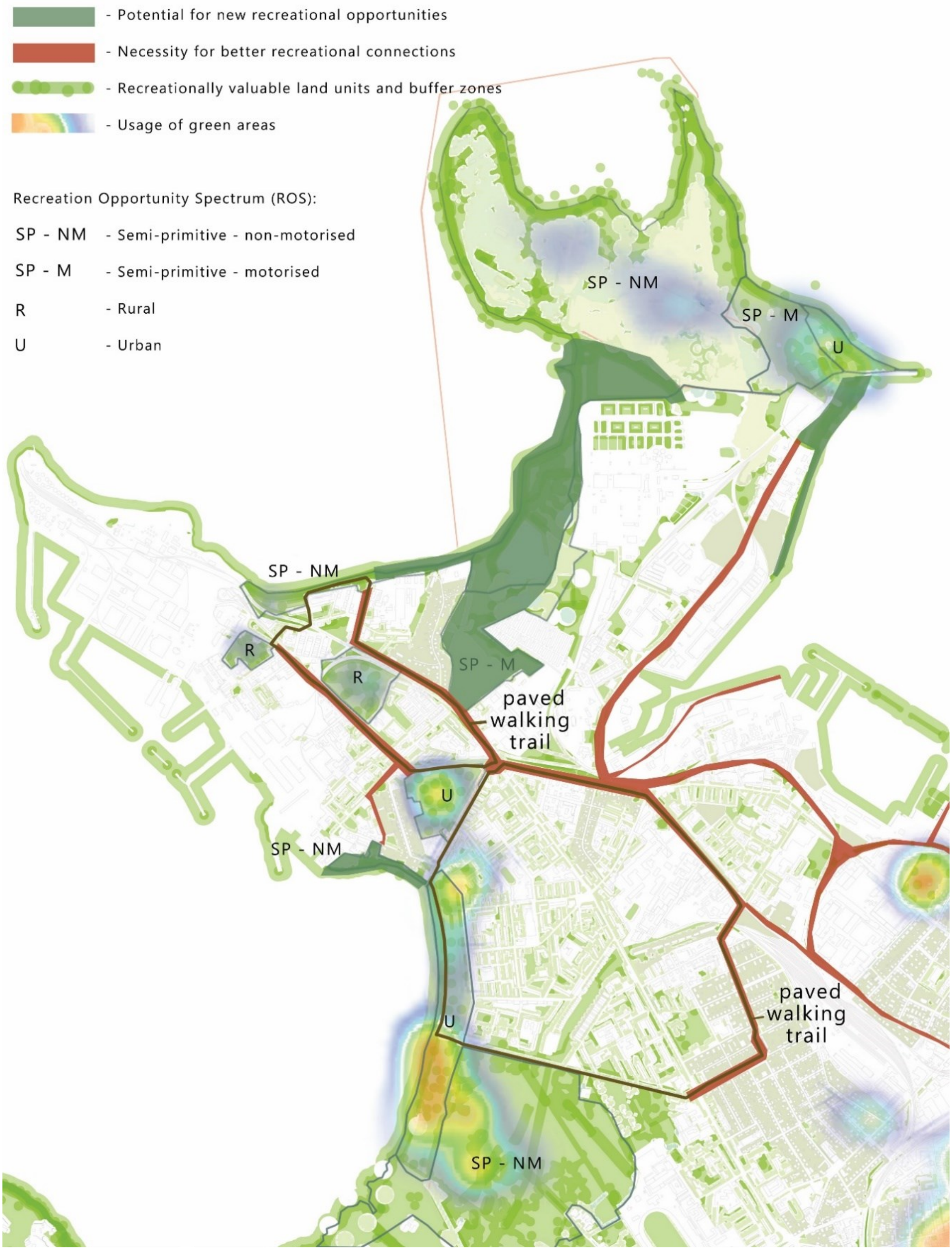

Figure 18. *Recreational layer – mapping of potential areas for new recreational opportunities and areas in necessity for better recreational connections*

Thirdly, recreational layer was overlapped with service providing units layer to locate where the necessity for green infrastructure connections and recreational connections overlap. It could be stated that the areas in need for better recreational and green mostly overlap. Future planning of the green infrastructure could cover both – ecological and recreational planning principles in similar areas. Furthermore, it is important to locate where the potential area for new recreational opportunities overlap with the zone of sensitive service providing land units. Areas overlapping with sensitive zones need more attention and careful planning – the protection of the sensitive areas has to be guaranteed (figure 19.).

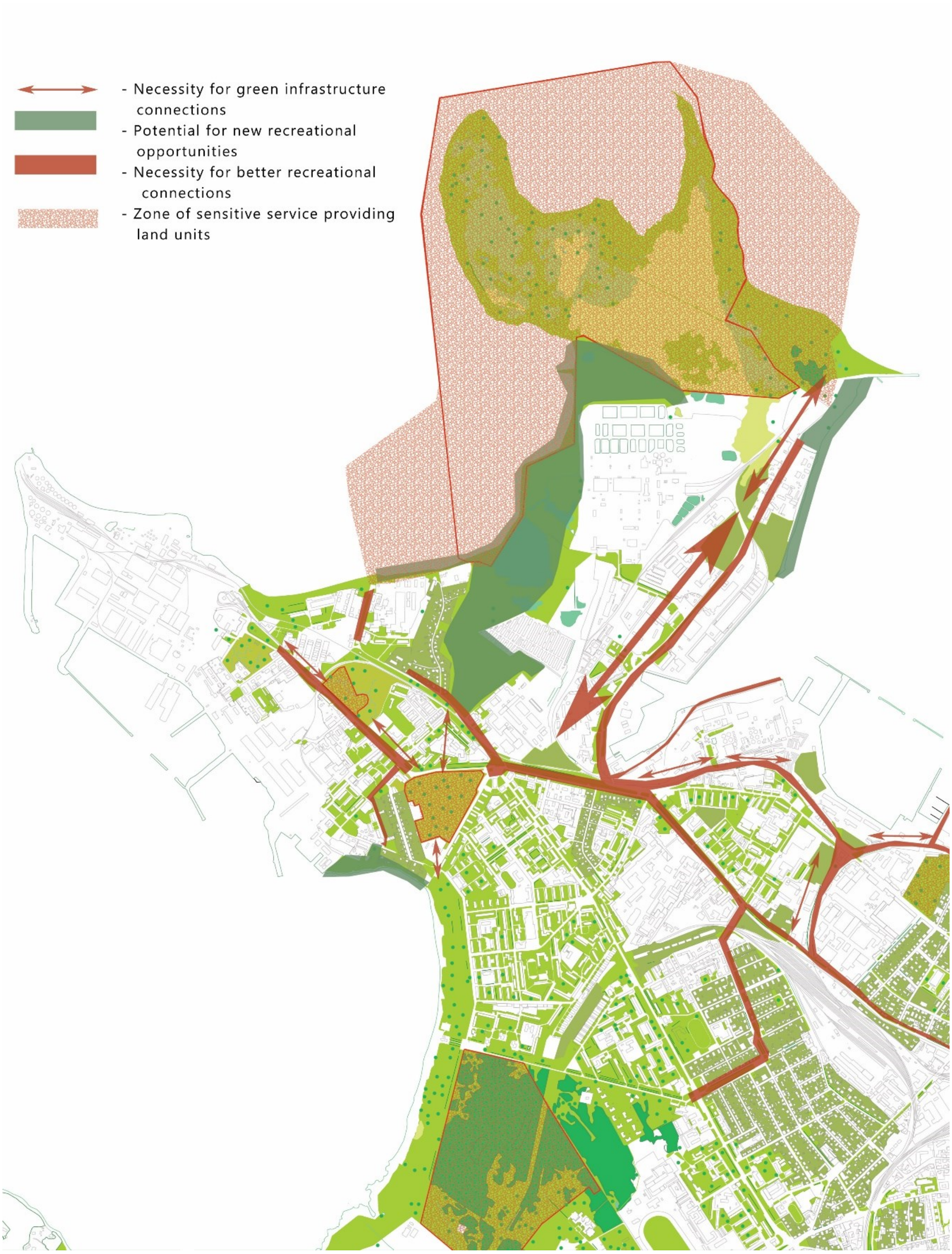

Figure 19. *Overlapped recreational and ecological layer*

Finally, the outcome of overlapping the ecological and recreational layer was overlaid with the map of future detailed plans to locate the future conflicts and synergic areas. Most conflicting detailed plan is the Paljassaare cross 16 detailed plan. It is partly covering the nature protection areas and not only with the beach promenade areas but also with housing. Rest of the housing area is planned on an area that has high potential for recreational opportunities and ecological connections. Kopli lines detailed plan is missing a small link for recreational connections. Similar conflicting areas are occurring also in Sirbi, Kopliranna and Vasara Street detailed plan. Paljassaare port detailed plan could include an important link to connect recreational and ecological connections to Paljassaare peninsula (figure 20.).

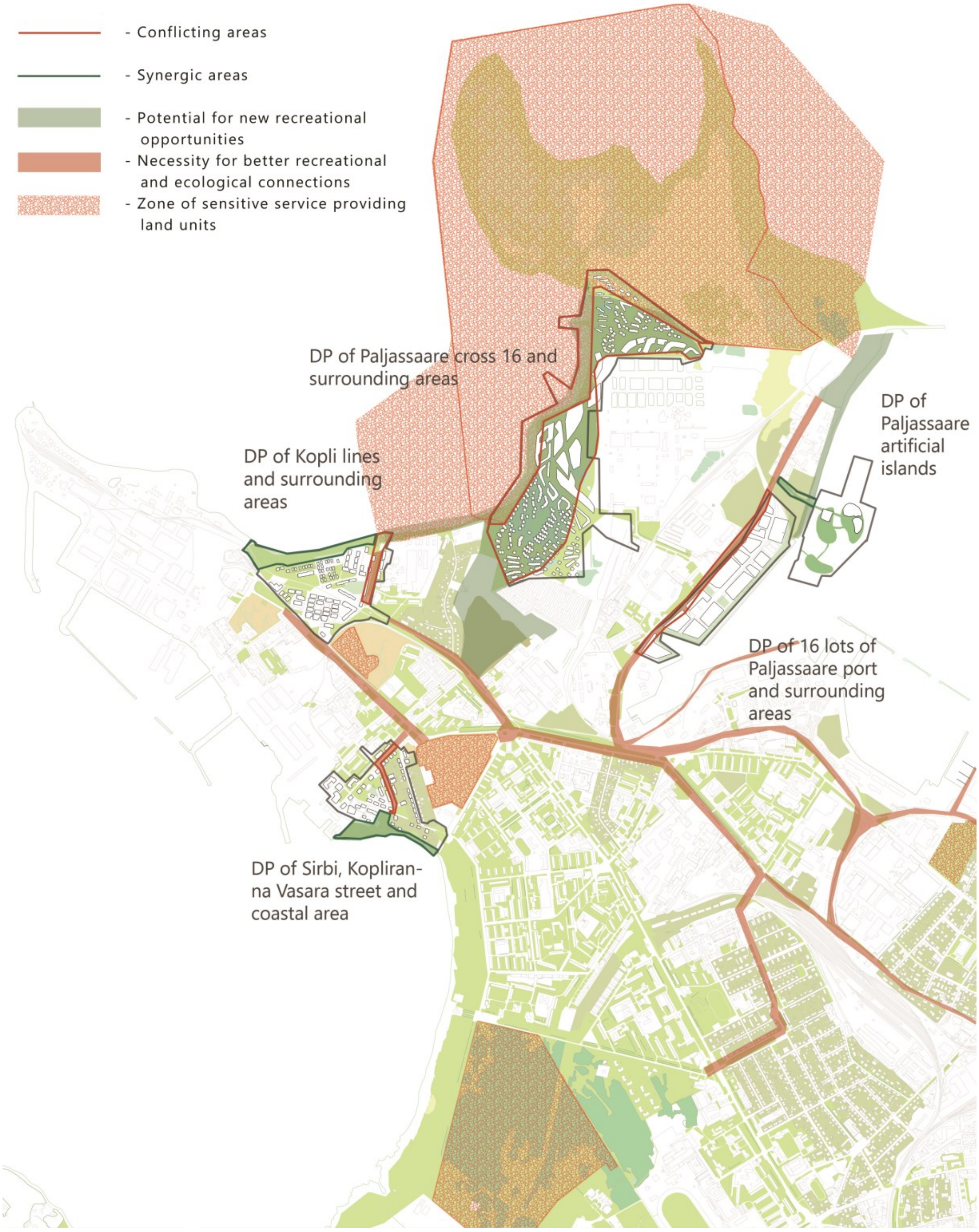

Figure 20. *Locating conflicting and synergic areas*

Previously localised conflicting areas can be addressed with following green infrastructure planning principles that are phrased according to the previous research for mitigating the current problematic conditions and threats in the prognosis for 2030.

3.5.2.2 Ecological planning principles

Most problematic conditions of the current state (chapter 3.3.3) are phrased into new planning principles for mitigating the prognosis for threats and conflicting areas:

1. New green infrastructure connections and connected distribution of SPU across the Northern Tallinn can be made by:

    1.1 Enlarging the areal range of canopy coverage

    1.2 Redesign built abandoned areas

    1.3 Developing more urban green spaces

    1.4 Increasing the area of pervious surfaces

2. Air quality can be improved by:

    2.1 Prevention of the concentration of O_3 exceeding the level of normative

Threats that are emerged from the political response according to the prognosis for 2030 are also included in the phrasing of four additional planning principles:

4. Slowing the increase of built up areas by using more sustainable solutions – pervious surfaces, sustainable urban drainage systems

5. Maintaining the size of the current nature reserve area

6. Eliminate the disturbance of bird species and species under protection

3.5.2.3 Recreational planning principles

Most problematic conditions of the current states (chapter 3.3.3) are phrased into a planning principle for mitigating the prognosis for threats and conflicting areas:

1. Creating recreational connections, facilities and parks that are linked to the coast line and Paljassaare peninsula

Threats that are emerged from the political response according to the prognosis for 2030 are also included in the phrasing of one additional planning principles.

2. The factor of publicness is comprehendible on the sites – people feel that they can use recreational areas to their everyday needs

3. Users of the recreational areas feel welcomed and included in the local society

4 DISCUSSION

The main research task was to propose a response for green infrastructure planning in Kopli and Paljassaare districts by phrasing new ecological and recreational planning principles and locating the conflicting and synergic areas. Previous studies done in similar research fields are including also the local planning policies into the analysis. Current thesis attempted to follow the EU strategies apart from the general plan of Northern Tallinn. Response was proposed by bringing out 5 conflicting and 3 synergic areas based overlapping layers of information (figure 20). 6 ecological and 3 recreational planning principles were proposed to mitigate the current problematic conditions, prognosis for threats and conflicting areas (chapter 3.5.2.2 and 3.5.2.3).

Proposed research questions were formed in order to find out the main topics of interest. To give answers the questions a structure had be compiled that would cover all the topics of interest and give complete overview of the research. So that the condition and distribution of ecological and recreational indicators could be assessed, current situation had be analysed on a larger scale. The MAES indicator framework introduced a set of key indicators to evaluate the condition of urban ecosystems (Maes *et al.* 2016). These indicators were divided into pressures and states. By following through with the framework it was understood that only relying on pressures and states is not sustainable solution for the thesis. The complete set of indicators had be assessed and DPSIR approach had to be included to interpret also drivers, impacts and offering a proposal in a form of a response.

Driving forces and pressures had to be included as a direction of change. Assessment of states gave answers to two main research questions – ecological and recreational condition and distribution. Impacts had to be interpreted to understand the consequence of change. Political response was included a form of five large scale detailed plans to locate threats that would occur in the future. Recreational indicators had be collected by using a similar method. Collected data about recreational indicators could be adjusted as drivers, current states and impacts. Finally, conflicting and synergic areas are located and a response based on green infrastructure planning principles is proposed as an answer to the two final research questions.

Anyone, who knows something about green infrastructure planning, has a brief overview of the current situation of the research area and knows the designed detailed plans, can assume which fragile combinations can cause problematic situations. This thesis has evidence and has brought out data about every problematic and conflicting situation (table 4, chapter 3.3.3.; figure 20.). Problematic conditions, conflicting areas and threats are caused by changes in current states and can be solved by using proposed planning principles in green infrastructure planning (chapter 3.5.2.2 and 3.5.2.3). By implementing these principles into green infrastructure planning of Northern Tallinn the problematic conditions and conflicting areas could have a solution. The environmental condition, public health and quality of life could be improved.

As mentioned in the chapter of methodology - identification of the study area (chapter 2 – 2.1), chosen research area was already assessed during a previous design project. Brief analysis done during the project already gave an overview of some problematic conditions: fragmented green infrastructure, large industrial areas with much impervious surfaces and lack of recreational opportunities. It was astonishing to find out additional problematic conditions about deficient range of canopy coverage and only high concentration of O_3 in the air (table 4.). With the nature reserve in the area it could be assumed that general range of canopy coverage is sufficient and with so many industrial grounds it could be presumed that the concentration of air pollutants is much higher.

At the beginning of the thesis writing process, it was intended to also submit the actual spatial planning of the green infrastructure in addition to the proposal of the planning principles. During the process it was acknowledged that the amount of work would need more time and data to be succeeded. Due to the large volume of the proposal it was only possible to assess this small area of interest. Applied methods could also be applied to a larger scale – throughout Northern Tallinn with connections to other parts of Tallinn, including areas near Noblessneri, the Tallinn port, Kalamaja district, Pelgulinna district and Telliskivi area.

It would be interesting to research further some of the aspects about green infrastructure planning in Northern Tallinn. The qualitative results of the inquiry about green areas in Estonia (Niin 2015) could also have been included to assess the opinion of people visiting those green areas. The level of precision was too general to include qualitative opinions into the thesis. In the future, if the outcome of the thesis would be included into more detailed planning of the green infrastructure, qualitative result of the inquiry could also be included to assess each green area more precisely. The results about the current conditions of states can be assessed more thoroughly. State indicators included in the assessment are the key indicators proposed in the MAES frameworks – additional indicators could be included in the research to have a more profound result. The service providing units could be categorised more precisely and mapped by doing site visits for more accurate data. Some green area marked with 40% of vegetation can carry actually more vegetation or have areas with no vegetation. A scientific assessment of impacts could be followed through to know the actual impacts that the changes in the states could cause. The most intriguing follow-up would be to proceed with the actual green infrastructure planning based on the proposed planning principles and stated conflicting areas.

SUMMARY

The main research task was to propose a response for green infrastructure planning in Kopli and Paljassaare districts by phrasing new ecological and recreational planning principles and locating the conflicting and synergic areas. Four research questions were stated:

1. Which ecosystem services are valid in the green infrastructure of Northern Tallinn district, what is their condition and where are these services distributed?
2. Which recreational opportunities are valid in the green infrastructure of Northern Tallinn, which landscape units are recreationally valuable and used by local residents, where are these features distributed?
3. Where are the conflicting and synergic areas considering the studied aspects of the green infrastructure?
4. Which planning principles need to be considered in the initial position of the green infrastructure planning?

Research area was chosen to connect three main green infrastructure hubs – Paljassaare Nature Reserve in the North, green area around Kaelajärv Lake in the centre and Merimetsa Greenland Conservation Area in the South. The DPSIR approach (drivers – pressures – states – impacts – response) is used through the thesis as a diagnostic and structuring tool for the assessment of the ecological as well as recreational indicators.

The first research question was answered by using The EU Biodiversity Strategy of 2020 and MAES indicator framework that offered many comprehensive reports on how to assess and map the states of ecosystem services and their conditions. By following the framework many problematic conditions emerged: deficient range of canopy coverage, highly fragmented landscape and green infrastructure, concentration of O_3 exceeding the level of normative, lack of urban green space, many built abandoned areas and impervious surfaces. The distribution of ecosystem services were mapped by linking ecosystem services to service

providing units (SPUs) to assess the current state and distribution of ecosystem services. Following ecosystem service providing units were valid in the areas: drinking water, regulation of air quality by urban trees and forests, climate regulation by reduction of CO_2, urban temperature regulation, noise mitigated by urban vegetation, water flow regulation and runoff mitigation, insect pollination, nature-based recreation and nature-based education. It was stated that the distribution of SPUs is fragmented in the central part of Northern Tallinn.

Answer to the second research question was reached by mapping recreationally valuable land units and interpreting them as drivers according to the DPSIR method. Land units that are considered recreationally valuable are: rapids, bigger rocks, slopes, shores of internal waters, streams, sea shore, piers, green areas, memorials, monuments, glade grasslands, trees, forests and light beacons. Current recreational opportunities were mapped and classified by using Recreational Opportunity Spectrum approach. Most of the recreation facilities are located in the western park of Northern Tallinn – Stroomi Beach Park and Kopli Cemetery Park. An inquiry was included in the research to locate current state of the usage of green. It was claimed that people use areas that are equipped and have more facilities - Stroomi beach, Merimetsa nature trail, Kopli Cemetery Park, Paljassaare Nature Reserve and Pikakari beach. It was generally stated that there is lack of recreational connections, facilities and parks that are linked to Paljassaare peninsula green areas.

The third research question was answered in the proposal for the response by overlapping ecological and recreational layer with the layer of political response. Conflicting and synergic areas were located by comparing the information carried out on each layer. 5 conflicting and 3 synergic areas were located in the mapping process. It was proved that the most conflicting detailed plan is the Paljassaare cross 16 and surrounding areas – The Ecobay. The Ecobay is partly covering the nature protection areas and not only with the beach promenade areas but also with housing areas.

The fourth research question was reached by stating new ecological and recreational planning principles for green infrastructure planning. Most problematic conditions of the current state are phrased into new planning principles for mitigating the prognosis of threats and conflicting areas. New green infrastructure connections and connected distribution of SPU across the Northern Tallinn can be made enlarging the areal range of canopy coverage, redesign built abandoned areas, developing more urban green spaces, increasing the area of pervious surfaces. Air quality can be improved by the prevention of the concentration of O_3 exceeding the level of normative. Slowing the increase of built up areas by using more sustainable solutions – pervious surfaces, sustainable urban drainage systems. Maintaining the size of the current nature reserve area by not making it available for construction. Eliminate the disturbance of bird species and species under protection. Creating recreational connections, facilities and parks that are linked to the coast line and Paljassaare peninsula. The factor of publicness is made comprehendible on the sites – people feel that they can use recreational areas to their everyday needs. Users of the recreational areas feel welcomed and included in the local society. By implementing these principles into green infrastructure planning of Northern Tallinn, the problematic conditions and conflicting areas could have a solution.

Proposed planning principles offer an initial input to the green infrastructure planning of Northern Tallinn. They offer general guidelines which are important to follow in order to mitigate the current problematic conditions and prognosis of threats in the conflicting areas. Future research to follow up this thesis would assess each proposed principles in a more detailed level and process each conflicting area in a smaller scale. These detailed plans included as a prognosis of threats can change and additional ones can be proposed as new threats.

Green infrastructure between large industrial areas can be planned by engaging proposed planning principles – the ecological and recreational quality of the district can be preserved and restored. Green connections between parks, nature reserve and seaside can be restored, maintained or rebuilt. Growing urban sprawl and built infrastructures do not need to break the connectivity of the green infrastructure– there are alternative measures for co-existence.

KOKKUVÕTE

Uurimuse põhiline eesmärk oli välja pakkuda rohetaristu planeerimise põhimõtted Kopli ja Paljassaare asumis, sõnastades uued ökoloogilised ja rekreatiivsed planeerimise põhimõtted ning kaardistades vastuolulised ja sünergilised asukohad. Põhilise uurimuseesmärgi saavutamiseks esitati neli uurimusküsimust:

1. Millised ökosüsteemi teenused asuvad Põhja-Tallinna rohetaristus, milline on nende seisund ning kus need teenused paiknevad?
2. Millised maastikuelemendid on rekreatiivselt väärtuslikud, milliseid alasid inimesed kasutavad ning kus need alad paiknevad?
3. Kus paiknevad vastuolulised ja sünergilised alad võttes arvesse kõiki uuritud aspekte rohetaristu kohta?
4. Milliseid planeerimise põhimõtteid tuleb arvestada rohetaristu planeerimisel?

Uurimusala valiti kolme suurema roheala ühendamiseks: põhjaosas asuv Paljassaare looduskaitseala, keskosas asuv Kaelajärve ümbritsev roheala ja lõunas asuv Merimetsa kaitseala. DPSIR (jõud – surve – seisund – mõju – vastumeede) metoodikat kasutatakse kui diagnostilist ja struktuuri loovat vahendit, nii ökoloogiliste kui ka rekreatiivsete indikaatorite hindamisel.

Esimesele uurimusküsimusele vastamiseks kasutati ELi bioloogilise mitmekesisuse strateegiat aastaks 2020 ja MAES (ökosüsteemi teenuste kaardistamine ja hindamine) indikaatorite tugiraamistikku, mille raames oli välja töötatud mitmeid raporteid ökosüsteemi teenuste seisundi hindamise ja kaardistamise kohta. Tugiraamistiku jälgimisel ilmnesid mitmed problemaatilised seisundid: vähene puude võra katvus, killustunud maastik ja rohetaristu, kõrge O_3 kontsentratsioon, linnalike rohealade puudus, liigselt oli hüljatud tehislike alasid ning vettpidavaid pindasid. Ökosüsteemi teenused kaardistati ühendades teenused konkreetsete maaüksustega, et hinnata ökosüsteemi teenuste hetkeseisu ja paiknemist. Kaardistatud ökosüsteemi teenused olid järgmised: joogivesi, õhukvaliteedi reguleerimine linnapuude ja metsade poolt, kliimaregulatsioon CO_2 vähendamise abil, linnakeskkonna temperatuuri reguleerimine, taimestikuga vähendatud müratase, veevoolu reguleerimine ja äravoolu vähendamine, putukate tolmeldamine, looduspõhine rekreatsioon ja looduspõhine haridus. Leiti, et ökosüsteemi teenuste paiknemine on suuresti killustunud just Põhja-Tallinna keskosas.

Vastus teisele uurimusküsimusele saadi rekreatiivselt väärtuslike maastikuelementide kaardistamise ja DPSIR meetodi kohaselt juhtivaks jõuks määramise teel. Maastikuelemendid, mis määratleti väärtuslikeks on kärestikud, suuremad kivimid, nõlvad, sisevete kaldad, ojad, merekaldad, jõed, haljasalad, mälestusmärgid, avarad rohumaad, puud, metsad ja tuletornid. Praegused rekreatiivsed võimalused kaardistati ja klassifitseeriti kasutades Rekreatsiooni Võimaluste Spektrit (ROS). Enamik puhkevõimalusi asub Põhja-Tallinna lääneosas - Stroomi rannapargis ja Kopli kalmistupargis. Uurimusse kaasati ka läbiviidud küsimustik rohealade kasutamise kohta Eestis. Väideti, et inimesed kasutavad pigem hästi varustatud, mitmete võimalustega alasid - Stroomi randa, Merimetsa loodusrada, Kopli kalmistuparki, Paljassaare looduskaitseala ja Pikakari randa. Üldiselt väideti, et kõige suurem rekreatiivsete ühenduste, parkide ja rajatiste puudus on Paljassaare poolsaare ja teiste alade vahel.

Kolmandale uurimusküsimusele selgub vastus vastumeetmete peatükis (peatükk 5.5.2.1), kus kõrvutatakse ökoloogiliste ja rekreatiivsete indikaatorite kiht poliitilise vastuse kihiga. Kolme kihi informatsiooni analüüsides on kindlaks määratud vastuolulised ja sünergilised piirkonnad. Kaardistamise protsessis määrati kindlaks viis vastuolulist ja kolm sünergilist piirkonda. Leiti, et kõige vastuolulisem on Paljassaare põik 16 ja lähiala planeering, mis kattub osaliselt looduskaitseala territooriumiga, mitte ainult rannapromenaadi alaga vaid ka hoonestusalaga.

Neljanda uurimusküsimuse vastus seisneb ökoloogiliste ja rekreatiivsete rohetaristu planeerimise põhimõtete ettepanekus. Praeguse olukorra kõige problemaatilisemad seisundid on sõnastatud uuteks planeerimise põhimõteteks, et leevendada käesolevat olukorda ja ära hoida prognoositavaid ohte vastuolulistel aladel. Uued rohetaristu ja ökoloogilisi teenuseid kandvaid maaüksusi saab ühendada suurendades puude võra katvust, ümber kujundades mahajäetud tehislikke alasid, planeerides linna rohealasid ja suurendades vett läbilaskvaid alasid. Õhu kvaliteeti saab parandada ennetades O_3 normaaltaseme ületamist. Tehislike pindade planeerimist saab pidurdada rakendades alternatiivseid meetodeid – vett läbilaskvad pinnad, säästvad drenaažisüsteemid. Looduskaitseala pindala saab säilitada hoonete rajamise keelustamisega. Kaitsealuste liikide häirime on välistatud. Rekreatsiooniliste ühenduste loomine, mis on seotud mereäärse ala ja Paljassaare poolsaarel olevate rekreatiivsete võimalustega. Avalikud alad on üheselt mõistetavad – inimesed tunnevad, et rekreatiivsed alad on kõigile suunatud igapäevaseks kasutamiseks. Rohealasid külastavad inimesed tunnevad ennast osana kohalikust kogukonnast. Rakendades esitatud põhimõtteid Põhja-Tallinna rohetaristu planeerimisse, saab leevendada hetke olukorda ja ära hoida prognoositavaid ohte vastuolulistel aladel.

Esitatud planeerimise põhimõtted saavad olla esimeseks sisendiks rohetaristu planeerimisel Põhja-Tallinnas. Planeerimise põhimõtetes on toodud välja üldised juhised, mis on olulised leevendamaks käesolevat olukorda ja prognoositavate ohtude ära hoidmiseks vastuolulistel aladel. Uurimust jätkates saaks edaspidi hinnata igat planeerimise põhimõtet sügavuti, üksikasjalikumalt ning töötada edasi iga vastuolulise alaga väiksemal skaalal. Prognoositavate ohtude välja selgitamiseks kaasatud detailplaneeringud võivad aja jooksul muutuda ning lisanduda võivad uued detailplaneeringud, mis võivad kaasa tuua uued ohud.

Suurte tööstuspiirkondade vahelist rohetaristut saab planeerida esitatud planeerimise põhimõtete kaudu – piirkonna ökoloogilist ning rekreatiivset kvaliteeti saab säilitada ja taastada. Roheühendused parkide, looduskaitsealade ja mereäärsete rohealade vahel on võimalik taastada, säilitada või ümber planeerida. Linnade laiendamine ja ehitatud infrastruktuurid ei pea rohetaristu ühendatavust katkestama – leidub alternatiivseid meetodeid kooseksisteerimiseks.

REFERENCES

© European Union. (2018). Copernicus Land Monitoring Service, - *European Environment Agency (EEA)*. Available at: https://land.copernicus.eu/pan-european.(14.04.2018)

AB Korrus. (2017). Explanatory note of Meeruse port area architectural draft. Tallinn.

Ahern, J. (2007). Green infrastructure for cities: the spatial dimension, - *Cities of the Future:Towards Integrated Sustainable Water and Landscape Management*, pp. 267–283. Available at:

http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Green+infrastructure+for+cities+:+The+spatial+dimension#0.(17.02.2018)

Ajuntament de Barcelona. (2013). Barcelona green infrastructure and biodiversity plan 2020, - *Barcelona, Spain (in Spanish, English summary)*, p. 113. Available at: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Barcelona+green+infrastructure+and+biodiversity+plan+2020.#0.(15.05.2018)

AS K-projekt. (2015). Explanatory note of Paljassaare cross 16 and surrounding areas detailed plan. Tallinn.

AS K-projekt. (2017a). Explanatory note of Paljassaare artificial islands detailed plan. Tallinn.

AS K-projekt. (2017b). Explanatory note of the Paljassaare port area detailed plan. Tallinn.

AS Sweco Project. (2009). Explanatory note of Sirbi, Kopliranna, Vasara and the area between the sea detailed plan. Tallinn.

Bell, S. (1997). Design for Outdoor Recreation. London: Spon Press: pp. 401.

Benedict, M. A., McMohan, E. and The Conservation Fund. (2012). Green infrastructure: Linking Landscapes and Communities. Island Press: pp.320.

Bio-Protection Research Centre. (2015). Service Providing Units (SPU), - *Lincoln University*. Available at:

http://www.lincoln.ac.nz/biodiversityfunction/Service-providing-units/ (12.03.2018).

Capotorti, G., Alós Ortí, M. M., Copiz, R., Fusaro, L., Mollo, B., Salvatori, E. and Zavattero, L. (2018). Biodiversity and ecosystem services in urban green infrastructure planning: A case study from the metropolitan area of Rome (Italy), - *Urban Forestry and Urban Greening*. Elsevier. pp. 1–10.

Davies, C. and Lafortezza, R. (2017). Urban green infrastructure in Europe: Is greenspace planning and policy compliant?, - *Land Use Policy*, 69(March), pp. 93–101.

Díaz, M. E., Figueroa, R., Alonso, M. L. S. and Vidal-Abarca, M. R. (2018). Exploring the complex relations between water resources and social indicators: The Biobío Basin (Chile), - *Ecosystem Services*, 31, pp. 84–92.

Dover, J. W. (2015). Green infrastructure: Incorporating plants and enhancing biodiversity in buildings and urban environments. pp.311.

Engineering bureau Stratum. (2010). Traffic prognosis report for Paljassaare and Ecobay detailed plans.

Environmental Studies Centre. (2012). The Interior Green Belt Towards an Urban Green Infrastructure in Vitoria-Gasteiz. Vitoria-Gasteiz.

EU-COM. (2011). Our life insurance, our natural capital: an EU biodiversity strategy to 2020. p. 17. Available at:

http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52011DC0244. (21.04.2018)

Europarc Federation. (2018). Webinar: Periurban Parks – Building Green Infrastructure around Cities. Available at:

http://www.europarc.org/news/2018/04/webinar-periurban-parks-green-infrastructure/. (13.05.2018)

European Commission. (2016a). MAES-related developments in Estonia, - *MAES-related developments in the European Union*. Available at:

https://biodiversity.europa.eu/maes/maes_countries/estonia.(15.04.2018)

European Commission. (2016b). Nature and Biodiversity Laws, - *Green infrastructure: In practice*. Available at: http://ec.europa.eu/environment/nature/ecosystems/index_en.htm (23.02.2018).

European Environment Agency. (2017). Air quality in Europe — 2017 report, - *EEA Technical Report*. pp.80.

European Environmental Agency. (2012). Landscape fragmentation in Europe, - *Joint EEA-FOEN report. EEA Report No 2/2011*. pp.92.

European Union. (2011). Mapping Guide for a European Urban Atlas. Available at: http://www.eea.europa.eu/data-and-maps/data/urban-atlas#tab-methodology (07.03.2018).

Everard, M. (2017). Ecosystem services: Key Issues. New York: Routledge: pp.188.

Gabrielsen, P. and Bosch, P. (2003). Environmental Indicators: Typology and Use in Reporting, - *European Environment Agency (EEA)*. pp.1-20.

Gari, S. R., Newton, A. and Icely, J. D. (2015). A review of the application and evolution of the DPSIR framework with an emphasis on coastal social-ecological systems, - *Ocean and Coastal Management*. Elsevier Ltd, 103, pp. 63–77.

Haines-Young, R. and Potschin, M. (2018). CICES (Common International Classification of Ecosystem Services) Guidance on the Application of the Revised Structure. Nottingham.

Hansen, R., Lorance, E. R., Werner, R. and Stephan, P. (2017). Urban Green Infrastructure Planning a guide for practitioners, - *Green Surge*. Freising, Munich: pp.94.

Herslund, L., Backhaus, A., Fryd, O., Jørgensen, G., Jensen, M. B., Limbumba, T. M., Liu, L., Mguni, P., Mkupasi, M., Workalemahu, L. and Yeshitela, K. (2017). Conditions and opportunities for green infrastructure - Aiming for green, water-resilient cities in Addis Ababa and Dar es Salaam, - *Landscape and Urban Planning*. Elsevier, (September 2015), pp. 0–1.

Jongman, R. H. G., Külvik, M. and Kristiansen, I. (2004). European ecological networks and greenways, - *Landscape and Urban Planning*, 68(2–3), pp. 305–319.

Joyce, K. and Sutton, S. (2009). A method for automatic generation of the Recreation Opportunity Spectrum in New Zealand, - *Applied Geography*.

Keskkonnaamet, T. (2018). Tallinna linna ja linnastu heitkoguste inventuur.

Keul, A. (2015). The fantasy of access: Neoliberal ordering of a public beach, - *Political Geography*. Elsevier Ltd, 48, pp. 49–59.

Konijnendijk, C. C. (2003). A decade of urban forestry in Europe, - *Forest Policy and Economics*, 5(2), pp. 173–186.

Kulczyk, S., Woźniak, E. and Derek, M. (2018). Landscape, facilities and visitors: An integrated model of recreational ecosystem services, - *Ecosystem Services*.

Leclercq, E. (2018). Privatisation of the Production of Public Space. Delft University of Technology.

Lindholst, A. C., Caspersen, O. H. and Konijnendijk Van Den Bosch, C. C. (2015). Methods for mapping recreational and social values in urban green spaces in the nordic countries and their comparative merits for urban planning, - *Journal of Outdoor Recreation and Tourism*. Elsevier, 12, pp. 71–81.

Low, S. M. (2006). The Erosion of Public Space and the Public Realm: paranoia, surveillance and privatization in New York City, 18(1), pp. 43–49.

Maa-amet (2018). Maa-amet map application. Available at: http://xgis.maaamet.ee/xGIS/XGis?app_id=UU82&user_id=at&bbox=341604.713698196,6376316.03922809,763395.286301804,6614848.14931984&LANG=1 (13.03.2018).

Maes, J., Zulian, G., Thijssen, M., Teller, A., Castell, C., Baró, F., Margarida, A. F., Melo, J., Garrett, C. P., David, N., Alzetta, C., Genelett, D., Cortinovis, C., Zwierzchowska, I., Alves, F. L., Cruz, C. S., Blasi, C., Alós Ortí, M. M., Attorre, F. *et al.* (2016). Mapping and Assessment of Ecosystems and their Services: Urban ecosystems. Luxembourg.

Maes, J., Teller, A., Erhard, M., Grizzetti, B., Barredo, J. I., Paracchini, M. L., Condé, S., Somma, F., Orgiazzi1, A., Jones1, A., Zulian1, G., Vallecilo, S., Petersen, J.-E., Marquardt, D., Kovacevic, V., Malak, D. A., Marin, A. I., Czúcz, B., Mauri, A. *et al.* (2018)

Mapping and Assessment of Ecosystems and their Services: An analytical framework for mapping and assessment of ecosystem condition in EU. pp. 105.

Martin, C. L., Momtaz, S., Gaston, T. and Moltschaniwskyj, N. A. (2016). A systematic quantitative review of coastal and marine cultural ecosystem services: Current status and future research, - *Marine Policy*. Elsevier, 74, pp. 25–32.

Maxim, L., Spangenberg, J. H. and O'Connor, M. (2009). An analysis of risks for biodiversity under the DPSIR framework, - *Ecological Economics*. Elsevier B.V., 69(1), pp. 12–23.

MEA (2003). Ecosystems and their services, - *Ecosystems and Human Well-being: A Framework for Assessment*, pp. 49–70.

Nahuelhual, L., Vergara, X., Kusch, A., Campos, G. and Droguett, D. (2017). Mapping ecosystem services for marine spatial planning: Recreation opportunities in Sub-Antarctic Chile, - *Marine Policy*. Elsevier Ltd, 81(April), pp. 211–218.

Ndubisi, F. (2003). Ecological Planning: A historical and comparative Synthesis. JHU Press: pp.304.

Ndubisi, F. O. (2014). The Ecological Design and Planning Reader. Edited by F. O. Ndubisi. Island Press: pp.632.

NGO Tallinn Bird Club (2006). Avifauna of Tallinn Green Areas. Tallinn.

Niin, G. (2015). Inquiry about green areas in nine Estonian towns. Estonian University of Life Sciences, Tartu.

Peng, J., Zhao, H. and Liu, Y. (2017). Urban ecological corridors construction: A review, - *Shengtai Xuebao/ Acta Ecologica Sinica*. Ecological Society of China, 37(1), pp. 23–30.

RAAM Arhitektid OÜ. (2009). Explanatory note of Kopli lines and surrounding areas detailed plan. Tallinn.

Saare, K., Kabral, N., Maasikmets, M. and Teinemaa, E. (2015). Välisõhu kvaliteedi seire 2014. Riiklik keskkonnaseire alamprogramm. Tallinn. Available at:

http://airviro.klab.ee/uploads/ohk2014.pdf. (14.03.2018)

Soop, K. (2014). Eesti mererekreatsiooni kontseptsioon Tallinna näitel. Estonian University of Life Sciences.

Stephenson, S. (2011). Abiotic , Biotic and Cultural Resource Survey for Land Planning Along the Rideau Canal Executive Summary i. Queens University. Available at:

https://qspace.library.queensu.ca/handle/1974/6526.(19.04.2018)

Tallinn City Planning Office. (2017). General Plan of Northern Tallinna - Version in process. Tallinn: pp.128.

Tallinn Statistic Atlas. (2018). Tallinn Statistic Atlas. Available at: http://statistika.tallinn.ee/citizmap.php?bookmark=11247256100c97d39b40e544fd396bab &view_type=table.

Tallinn, T., Sibul, J., Levald, A. and Pukkonen, E. (2008). Thematic Plan for Tallinn Green Areas. Available at: http://www.tallinn.ee/est/ehitus/g6479s42710.

The European Topic Centre on Spatial Information and Analysis. (2015). MAES Digital Atlas. Available at: https://biodiversity.europa.eu/maes/maes-digital-atlas. (18.02.2018)

United States Department of Agriculture. (1982). ROS Users Guide. pp.38.

Urban Atlas. (2012). Urban Atlas 2012. Available at:

https://land.copernicus.eu/local/urban-atlas/urban-atlas-2012?tab=mapview.(18.02.2018)

Uustal, M. and Peterson, K. (2006). Changes in the avifauna of Tallinn 1900-2005. Tallinn.

Vassiljev, P. (2018). Recreationally valuable areas buffered from GIS data. Estonian University of Life Sciences, Tartu.

Veersalu, T. (2009). Roheline võrgustik omavalitsuse planeeringu tasandil viimsi vallas. Estonian University of Life Sciences.

ANNEX 1

Pressures on urban ecosystems	
Class	**Indicator**
Urban sprawl	Percent of built up area (%)
Air pollution	Concentration of CO2 (%)
State indicators of urban ecosystems – built infrastructure	
Class	**Indicator**
Population density	Number of inhabitants per km²
Land use intensity	Artificial area per inhabitant
Road density	Length of the roads per km²
State indicators of urban ecosystems – green infrastructure	
Class	**Indicator**
Urban forest pattern	Canopy coverage (ha)
Connectivity of urban green infrastructure	Connectivity of GI (%)
	Fragmentation of GI (Mesh density pixel)
	Fragmentation of artificial area (Mesh density pixel)
State indicators related to the proportion of green and build infrastructures	
Class	**Indicator**
Land use	Proportion of urban green space (%)
	Proportion of natural areas (%)
	Proportion of protected areas (%)
	Proportion of abandoned areas (%)
	Proportion of impervious surface (%)
Indicators of urban biodiversity	
Class	**Indicator**
Species diversity	Number of bird species per km²
Conservation	Number of species under protection per km²
Introductions	Number of alien species

Annex 1. Indicator framework for measuring the condition of urban ecosystems (Maes *et al.* 2016: p. 78)

Lihtlitsents lõputöö salvestamiseks ja üldsusele kättesaadavaks tegemiseks

ning juhendajate kinnitus lõputöö kaitsmisele lubamise kohta

Mina, Kertu Kruus, (sünnipäev 30.07.1993),

1. annan Eesti Maaülikoolile tasuta loa (lihtlitsentsi) enda loodud lõputöö,
Proposal of green infrastructure planning principles in Kopli and Paljassaare district,
mille juhendaja on Gloria Niin, Peeter Vassiljev ja Mart Külvik,

   1.1 salvestamiseks säilitamise eesmärgil,

   1.2 digiarhiivi DSpace lisamiseks ja

   1.3 veebikeskkonnas üldsusele kättesaadavaks tegemiseks

kuni autoriõiguse kehtivuse tähtaja lõppemiseni;

2. olen teadlik, et punktis 1 nimetatud õigused jäävad alles ka autorile;

3. kinnitan, et lihtlitsentsi andmisega ei rikuta teiste isikute intellektuaalomandi ega isikuandmete kaitse seadusest tulenevaid õigusi.

Lõputöö autor ______________________________
allkiri

Tartu, 23.05.2018

Juhendajate kinnitus lõputöö kaitsmisele lubamise kohta

Luban lõputöö kaitsmisele.

Gloria Niin ______________________________ ____________________
(juhendaja nimi ja allkiri) (kuupäev)

Peeter Vassiljev______________________________ ____________________
(juhendaja nimi ja allkiri) (kuupäev)

Mart Külvik______________________________ ____________________
(juhendaja nimi ja allkiri) (kuupäev)